VCS Methodology

M0253

IMPROVED MANAGEMENT IN PADDY RICE PRODUCTION SYSTEMS

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Sectoral Scope 14

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CONTENTS

1 SOURCES ... 4

2 SUMMARY DESCRIPTION OF THE METHODOLOGY ... 4

3 DEFINITIONS ... 5

4 APPLICABILITY CONDITIONS ... 8

5 PROJECT BOUNDARY ... 9

6 BASELINE SCENARIO ... 11

7 ADDITIONALITY ... 13

8 QUANTIFICATION OF ESTIMATED GHG EMISSION REDUCTIONS ... 17

8.1 Summary ... 17

8.2 Baseline Emissions ... 21

8.3 Project Emissions ... 31

8.4 Leakage Emissions ... 35

8.5 Uncertainty ... 39

8.6 Estimated GHG Emission Reductions ... 43

9 MONITORING ... 46

9.1 Monitoring Requirements for Quantification Approach 2 ... 48

9.2 Data and Parameters Available at Validation ... 49

9.3 Data and Parameters Monitored ... 56

9.4 Description of the Monitoring Plan ... 77

10 REFERENCES ... 78

APPENDIX 1: GUIDANCE FOR DIGITAL MONITORING, REPORTING, AND VERIFICATION (DMRV) ... 80

APPENDIX 2: N_2O CORRECTION FACTOR ... 84

APPENDIX 3: ADDITIONAL GUIDANCE FOR SURROGATE PROCESS MODELS ... 86

APPENDIX 4: DOCUMENT HISTORY ... 87

1 SOURCES

This methodology is based on the following methodologies:

- *VM0042 Methodology for Improved Agricultural Land Management, v2.0*
- Clean Development Mechanism (CDM) *AMS-III.AU Methane Emission Reduction by Adjusting Water Management Practice in Rice Cultivation, v4.0*
- CDM *MP93-A03 Draft Small-scale Methodology: Emission Reduction by Application of Dry-cultivated Water-saving and Drought-resistance Rice (D-WDR) in Rice Cultivation*

This methodology uses the latest versions of the following tools, modules and guidelines:

- *VMD0053 Model Calibration, Validation, and Uncertainty Guidance for the Methodology for Improved Agricultural Land Management*
- *CDM Tool for Testing Significance of GHG Emissions in A/R CDM Project Activities*
- *CDM TOOL 01 Methodological Tool: Tool for the demonstration and assessment of Additionality*
- *CDM TOOL16 Methodological Tool: Project and Leakage Emissions from Biomass*
- *CDM TOOL 21 Methodological Tool: Demonstration of additionality of small-scale project activities*
- *CDM TOOL24 Methodological Tool: Common Practice*
- *CDM Guidelines for objective demonstration and assessment of barriers*

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality and Crediting Method	
Additionality	Project method
Crediting Baseline	Project method

This agricultural land management (ALM) methodology provides procedures to estimate the greenhouse gas (GHG) emission reductions (CH_4, N_2O, and CO_2) resulting from the adoption of improved management practices in paddy rice production systems.

The methodology is compatible with sustainable agriculture and has a particular focus on reducing methane (CH_4) emissions from the cultivation of paddy rice. Practices that are expected to result in material declines in soil organic carbon (SOC) are not eligible under this methodology. Projects that seek credits for SOC stock increases, or that employ practices that result in material declines in SOC should use *VM0042*.

The crediting baseline and additionality are determined via a project method. The baseline scenario assumes continuously flooded rice paddies and the continuation of historical rice cultivation practices. The management practices in the baseline scenario are determined by applying a historical look-back period to produce an annual schedule of activities (i.e., irrigation, planting, fertilization, and harvest events) for each quantification unit within the project area (e.g., for each field).[1] Each project must include activities that materially reduce soil methanogenesis (reducing CH_4 emissions) and may optionally include further practices including avoided biomass burning (reducing CH_4 and N_2O emissions), more efficient nitrogen fertilizer usage (reducing N_2O emissions), and more efficient fossil fuel usage (reducing CO_2 emissions). Any quantitative adjustment in optional further practices (e.g., decrease in fertilizer application rate and/or fossil fuel use) must exceed 5% of the pre-existing value to qualify as a practice change.

Additionality is demonstrated by a barrier analysis and a common practice test to determine that the practice change implemented under the project activity is not common practice.

Reductions are quantified using multiple optional approaches, including the use of biogeochemical modeling, direct measurements of CH_4 emissions, and default equations and emission factors. Available options differ depending on the GHG pool or source being assessed and the scale of the project. See Table 4 for a summary of allowable quantification options and section 8.1 for the details of each approachTable 4Table 4.

3 DEFINITIONS

In addition to the definitions set out in the *VCS Program Definitions*, the following definitions apply to this methodology.

Alternate wetting and drying (AWD)
A system of cultivating irrigated lowland rice using controlled and intermittent irrigation cycles (i.e., single or multiple drainage events during the cultivation period). This water management technique uses much less water than the usual system of maintaining continuous standing water in the crop field (i.e., continuous flooding). A periodic drainage and re-flooding irrigation

[1] ALM project proponents must periodically reassess the project baseline. See the most recent version of the *VCS Standard* for further details on baseline re-assessment requirements.

schedule is followed, and the water level must reach -15 cm below the soil surface during the entire drainage period.

Avoided burning

Residue management system in which residue (e.g., rice straw) is not burned after harvest.

Baseline control site

Defined area that is managed according to pre-project (baseline) practices (as set out in the schedule of activities) for direct measurement of CH_4. It is linked to and representative of the land and management practices in one or more quantification units and/or strata. Baseline control sites may be within or outside of the project area.

Continuously flooded rice paddies

Rice paddies cultivated in water-logged soils where the land is flooded before puddling, then continuously flooded until crop maturity (i.e., a few days before harvesting).

Controlled irrigation

A type of water management in the water regime (i.e., amount and timing of water application) is fully controlled.

Cultivation period

The period of time that begins with pre-planting field preparation on rice paddies and ends at the harvest event.

Direct seeded rice (DSR)

A system of cultivating rice in which seeds, either pre-germinated or dry, are broadcast or sown directly in the field under dry or wet conditions. No transplanting process is involved.

Digital monitoring, reporting, and verification (dMRV)

Tools used to enable the digital capture, analysis, tracking, and dissemination of data to enable monitoring, reporting, and verification.

Dry-cultivated water-saving and drought-resistant rice (D-WDR)

A variety of rice growing under rain-fed or dry cultivation systems with minimal standing water, maintaining soil aerobic conditions.

Furrow irrigation

A method of watering croplands in which farmers flow water down trenches (i.e., furrows) that have been dug alongside each crop row.

Historical look-back period

The time period prior to the project start date covering at minimum three years and three complete crop rotation. The historical look-back period is used to produce the schedule of activities.

Liming
The agricultural practice of applying lime or limestone to soil to neutralize soil acidity, improve soil structure, and provide essential nutrients like calcium and magnesium.

Methanotrophs
Organisms that occur naturally or are introduced to an environment and metabolize CH_4 to obtain their energy, thereby removing CH_4 from their environment.

Quantification unit
Defined area within the project for which GHG emission reductions are estimated using the selected quantification approach. The entire project area is divided into multiple quantification units that must be demonstrated to be homogenous for the purposes of estimating reductions (i.e., similar management activities, soil type, climate). Estimates of reductions for each quantification unit within the project area are then aggregated to produce an estimate for the entire project area. Quantification units must be clearly defined in the description of the sampling design provided in the project description.

Rainfed and deep-water
A type of water regime in which fields are flooded for a significant period of time and irrigation depends solely on precipitation, there is no controlled irrigation systems.

Sample point
Sample location of undefined area.

Schedule of activities
Annual schedule of historical management/activity practices applied in the baseline scenario over the historical look-back period (e.g., irrigation, fertilizer usage, and biomass amendments). These practices are determined following the data requirements given in Box 1.

Small-scale project
Under this methodology, projects with annual GHG emission reductions at or under 60 000 t CO_2e are eligible to utilize a simplified quantification approach.

Soil methanogenesis
Microbial production of CH_4 gas in soils by certain microorganisms breaking down organic matter in anoxic conditions, like waterlogged soils.

Transplanted rice
A system of planting rice where seeds are raised in a nursery bed for 20 to 30 days. The young seedlings are then directly transplanted into flooded rice fields.

Upland
A type of water regime in which fields have well-drained soil, without surface water accumulation, therefore its is never flooded for a significant period of time.

Water regime

A combination of rice ecosystem type (e.g., irrigated, rainfed, deep water) and flooding pattern (e.g., continuously flooded, intermittently flooded).

Woody/non-woody biomass

Under this methodology, woody biomass comprises parts with a substantial woody or lignin-based structure (e.g., the culm in rice). Non-woody biomass includes aboveground biomass (e.g., rice straw) and belowground biomass (e.g., root systems).

4 APPLICABILITY CONDITIONS

This methodology applies to improved rice cultivation practices that decrease net emissions of CH_4, N_2O, and/or CO_2. The methodology is globally applicable.

This methodology is applicable under the following conditions:

1) Projects must implement improved irrigation management practices that result in CH_4 emission reductions from methanogenesis (i.e., "main project activities"), including at least one of the following:
    a) Alternate wetting and drying (AWD)
    b) Use of direct seeded rice (DSR)
    c) Use of dry-cultivated water-saving and drought-resistance rice (D-WDR)
2) Projects may implement additional activities to further reduce CH_4 emissions and/or reduce N_2O and/or CO_2 emissions (i.e., "optional project activities"), including:
    a) Use of methanotrophs[2]
    b) Furrow irrigation or cultivation of row rice[2]
    c) Shortening of cultivation periods (e.g., via introduction of new cultivars)
    d) Avoided burning of rice residues
    e) Improvements in fossil fuel use efficiency
    f) Improvements in nitrogen management (i.e., reduction in N-application rate and/or the use of nitrification inhibitors or slow-release N-fertilizers)
3) Projects that introduce or implement quantitative adjustments (e.g., decrease in fertilizer application rate, decreased burning of rice straw residues, or use of fossil fuels) must exceed five percent of the pre-existing value of annual emission reductions

[2] Projects implementing the use of methanotrophs must undertake gas field measurement for the quantification of CH4 emissions.

of all fields under the project area. This emission reduction is calculated as the average value over the historical look-back period, developed for the baseline schedule of activities (see Section 6).

4) The project rice fields are equipped with controlled irrigation and drainage facilities such that appropriate dry/flooded conditions can be established during both dry and wet seasons (unless the practice employed to reduce CH_4 emissions does not require irrigation changes (i.e., through the use of methanotrophs).
5) The introduced project activity(ies) is/are not subject to any local regulatory restrictions.
6) Project activities do not represent a change in land use.
7) The project area has not been cleared of native ecosystems within the 10 years immediately preceding the project start date.

This methodology is not applicable under the following conditions:

8) Practices that result in material declines in SOC or the carbon input rate to soils. For example, increased rice straw removal, decreased application of manure or compost, and introduction of new cultivars known to have a materially smaller root system than the cultivar(s) used in the baseline.[3]
9) Rice is grown under upland, rainfed, or deep-water rice production techniques.
10) Projects change off-season (i.e., outside of the cultivation period) management practices (e.g., crop rotations, crop types, and/or livestock management must not deviate from historical off-season management practices).[3]

5 PROJECT BOUNDARY

The spatial extent of the project boundary is all lands on which the proposed rice cultivation activities will be implemented.

Carbon pools included in the project boundary in the baseline and monitoring periods are listed in Table 1: Selected carbon pools in the baseline and project scenarios

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[3] Projects that seek credits for SOC stock increases or employ practices that result in material declines in SOC must use *VM0042.*

Table 1: Selected carbon pools in the baseline and project scenarios

Source	Included?	Justification/Explanation
Aboveground and belowground woody biomass	No	Carbon pool is not included because it is not subject to significant changes or potential changes are transient in nature.
Aboveground and belowground non-woody biomass	Yes	Carbon pool is included because it is subject to significant changes, which can cause material flux changes in SOC, CH_4, and N_2O.
SOC	No	Practices that are expected to result in material declines in SOC are not eligible under this methodology.[3]

GHG sources included in the project boundary in the baseline and monitoring periods are listed in Table 2Table 2 below. Specific carbon pools and GHG sources may be deemed de minimis and need not be accounted for (i.e., value set to zero) where together the omitted decrease in carbon stocks (in carbon pools) and increase in GHG emissions (from GHG sources) amounts to less than 5% of the total GHG benefit generated by the project. This includes sources and pools that cause project and leakage emissions. This and all subsequent references to de minimis demonstration are conducted via application of the most recent version of the CDM *Tool for testing significance of GHG emissions in A/R CDM project activities.*

Table 2: GHG sources included in or excluded from the baseline and project scenario

Source	GHG	Included?	Justification/Explanation
Soil methanogenesis	CH_4	Yes	Changes in levels of anoxic conditions in soils lead to significant changes in soil methanogenesis. This is the dominant GHG source under this methodology.
Fossil fuels	CO_2	S*	Where there are changes in the use of equipment such as tractors, seeders, harvesters, or irrigation pumps, these changes may result in material increases or decreases in CO_2 emissions associated with the combustion of fossil fuels.
Liming	CO_2	S*	Application of limestone or dolomite as soil amelioration may represent a significant source of CO_2.
Enteric fermentation	CH_4	No	Projects that are expected to result in material changes in livestock management are not eligible under this methodology. Projects that seek credits for livestock management changes should use *VM0042*.
Manure deposition	N_2O CH_4	No	Projects that are expected to result in material changes in livestock management are not eligible under this methodology. Projects that seek credits for livestock management changes should use *VM0042*.
Use of nitrogen fertilizers and	N_2O	Yes	Where nitrogen fertilization and/or the volume of rice straw incorporated into soils is greater in the

nitrogen derived from crop residue (i.e., rice straw) incorporated into soils			monitoring period relative to the baseline scenario, N_2O emissions must be included in the project boundary. In all projects N_2O attributed to changes in irrigation must be included.
Biomass burning	CH_4	S*	Biomass burning releases CH_4.
	N_2O	S*	Biomass burning releases N_2O.
	CO_2	No	Such emissions are considered biogenic.

S* – Must be included where the project activity significantly increases emissions (i.e., by more than 5%) compared to the baseline scenario and may be included where the project activity reduces emissions compared to the baseline scenario. The 5% increase or reduction in GHG emissions must be calculated based on the total GHG benefit generated by the project.

6 BASELINE SCENARIO

The baseline scenario is the continuation of conventional flooded rice paddy cultivation practices. For each quantification unit (e.g., for each field), baseline scenario practices are set to match the practices implemented in the historical look-back period, creating a schedule of activities. The historical look-back period must be at least three years in duration. This same schedule of activities is then used to establish project emission reductions during each monitoring period.

The schedules of activities for the baseline and monitoring period must contain information on dynamic conditions, including irrigation patterns before and during the cultivation period, the type and amount of synthetic N fertilizers and organic amendments, and the duration of the cultivation season. All the data from these dynamic activities are critical and mandatory for the stratification of project areas into homogenous quantification units

Static conditions (e.g., soil type and climatic zone) are required when modeling under Quantification Approach 1 and may optionally be used for stratification when using Quantification Approach 2.

Activities relevant to the schedule of activities are summarized in Table 3 below, including whether each is mandatory or optional for baseline setting and stratification.

For Quantification Approach 2, at least one baseline control site[4] is required per stratum, as set out in Section 9.1.

Where baseline practices change materially during the historical look-back period with respect to the mandatory criteria, a separate schedule of activities must be developed for each year in

[4] See Section 3 for a definition of baseline control site.

the historical look-back period. In this case, project proponents must select the most conservative (lowest emissions) of the three schedules and use that for the baseline schedule of activities for the duration of the crediting period.

In circumstances where climatic conditions result in a monitoring period's cultivation season lasting longer than the baseline cultivation season, project proponents may set the baseline cultivation season duration using monitoring period data derived from baseline control sites. At least one baseline control site is required per stratum. The data (number of days in the cultivation season) must be derived from sources listed in Box 1, including those data retrieved from farmers surveys, and/or satellite images.[5]

Table 3: Schedule of activities and stratification guidance

Parameters	Type	Values/Categories	Optional/Mandatory for Stratification
Water regime – on-season	Dynamic[(a)]	Continuously flooded	Mandatory
		Single	
		Multiple drainage	
Water regime – pre-season	Dynamic	Flooded	Mandatory
		Short drainage (<180 days)	
		Long drainage (>180 days)	
Organic amendment (application rate)	Dynamic	No organic amendment	Mandatory
		Low, medium, high organic amendment	
Organic amendment (type)	Dynamic	Straw on-season	Mandatory
		Green manure	
		Straw off-season	
		Farmyard manure	
		Compost	
		No organic amendment	
Cultivation season duration	Dynamic	Cultivar-dependent	Mandatory
Nitrogen fertilizer application	Dynamic	<100 kg N/ha 100–200 kg N/ha 200–300 kg N/ha >300 kg N/ha	Mandatory
Soil pH	Static[(b)]	<4.5	Optional

[5] This ensures that baseline conditions are dynamic and project proponents are not unduly penalized for changes in climatic conditions that are outside of their control.

		4.5–5.5	
		>5.5	
Soil organic carbon	Static	<1%	Optional
		1–3%	
		>3%	
Climate	Static	Agro-ecological zone	Optional

[(a)]Dynamic conditions are subject to changes over time whether due to management or other reasons (e.g., climatic conditions such as droughts events).
[(b)]Static conditions are site-specific parameters less prone to changes over time and thus initially must be determined only once for a project and the corresponding fields (i.e., for the assessment of baseline).

The practices assumed in the baseline scenario must be re-assessed in accordance with the requirements of the most recent version of the *VCS Standard* and revised, where necessary, to reflect current cultivation practices in the region.[6]

7 ADDITIONALITY

This methodology uses a project method to demonstrate additionality. Project proponents using this methodology must:

1) Demonstrate regulatory surplus;
2) Identify barriers that would prevent implementation of a change in pre-existing rice cultivation practices; and
3) Demonstrate that adoption of the main project activity and/or suite of proposed optional project activities is not common practice.

These steps are described in more detail below.

Step 1: Regulatory Surplus

The project proponent must demonstrate regulatory surplus in accordance with the rules and requirements set out in the latest version of the *VCS Standard.*

Projects must take into account existing and forthcoming government policies or legal requirements that directly impact rice paddy production, such as restrictions on water usage or burning biomass, when analyzing regulatory surplus.

[6] See Section 3.2.7 of the *VCS Standard*, *v4.7* (or equivalent in most recent version).

Step 2: Identify barriers that would prevent implementation of a change in pre-existing rice cultivation practices

The project proponent must determine whether one or more distinct barrier(s) to project implementation exist.[7] These may include:

1) Investment barrier: Project faces capital or investment return constraints that can be overcome by the additional revenues associated with the sale of GHG credits

2) Technological barrier: Project faces technological-related barriers to implementation

3) Institutional barrier: Project faces financial (other than identified in investment barrier above), organizational, cultural, or social barriers that the VCU revenue stream can help overcome.

Demonstration of implementation barrier(s) must follow procedures set out in the latest version of the *CDM TOOL 01: Tool for the demonstration and assessment of additionality* and the latest version of the latest approved version of the *CDM Guidelines for objective demonstration and assessment of barriers.*

Step 3: Demonstrate that adoption of the main project activity(ies) and/or suite of proposed optional project activities is not common practice

The project proponent must determine whether the proposed project activity(s) is common practice[8] in each region included within the project spatial boundary. Evidence must be provided in the form of publicly available information contained in:

1) Agricultural census or other government (e.g., survey) data;
2) Peer-reviewed scientific literature;
3) Independent research data;
4) Attestation statement from a qualified independent local expert (e.g., accredited agronomists affiliated with official agricultural institutions supporting rice production such as the International Rice Research Institute);
5) Grower survey conducted within the project region;
6) Reports or assessments compiled by industry associations; or
7) Data compiled using remote sensing datasets.

[7] Project proponents citing technological and institutional barriers must apply the requirements in Section 3.5.4 of the *VCS Methodology Requirements, v4.4*. Project proponents using an investment barrier analysis must apply the requirements in Section 3.5.5 of the *VCS Methodology Requirements, v.4.4*.
[8] The precedent for a common practice threshold established in Section 18 of the CDM TOOL 24 - *Methodological tool: Common practice* is 20%.

To demonstrate common practice, the project area must be stratified to the state or provincial level (or equivalent second-order jurisdiction) in the countries where the project is being developed. Where supporting evidence is unavailable at the state/provincial level (e.g., in developing countries), aggregated data or evidence at a national or regional level may be used with justification. Where stratification based on geopolitical boundaries is impractical (e.g., due to lack of data), other forms of stratification, such as major soil types or cropping zones, may be used with justification. The same stratification approach and data sources must be applied across the entire project to maintain the integrity of the common practice demonstration. Where a data source is unavailable for a subset of the project region, justification must be provided for use of a different data source.

The list of project activities used for the demonstration of common practice is outlined in Section 4. The analysis must be conducted separately for main project activities[9] and optional project activities[10] as follows:

1) The project proponent must assess whether the main project activity(ies) reducing soil methanogenesis is common practice with a penetration rate greater than 20%. To be eligible, the penetration rate of each single proposed main project activity must be below 20%.

2) The project proponent must also assess whether a single or suite[11] of optional project activity(s) is common practice. For this assessment, the project proponent must show that the weighted mean adoption rate of the two (or more) optional project activities[12] within the project spatial boundary is below 20%[13] (see Equation (1)). Therefore, an individual activity with an existing adoption rate in the relevant region less than or equal to 20% is always considered additional. Where the adoption rate of one activity (e.g., furrow irrigation) is greater than 20%, the project must include a proportionally higher ratio of other activities with lower adoption rates (e.g., avoided burning of residues or fossil fuel use) to bring the weighted average of proposed project activities below 20%. An individual activity with an existing adoption rate greater than 20% may only be considered additional through the assessment of the weighted mean adoption rate for all project lands within that region.

   To calculate the weighted mean adoption rate in each region covered by the project area, Equation (1) must be applied.

[9] Main project activities exclusively improve irrigation management resulting in CH4 emission reductions from methanogenesis; see section 4 (Applicability condition #1).
[10] Optional project activities further reduce CH4 emissions and/or reduce N2O and/or CO2 emissions.
[11] The suite of activities refers to all optional project activities implemented across the aggregated project. It does not refer to the activities implemented on each individual farm.
[12] Determined based on the extent of the project area (i.e., hectares) covered.
[13] Where a project is planning to implement two additional project activities, common practice must be assessed based on the weighted mean of those two activities. Where only one activity is implemented, common practice must be assessed solely based on that activity's adoption rate (i.e., the adoption rate of that activity must be below 20%).

$$AR_r = (EA_{a1} \times PA_{a1}) + (EA_{a2} \times PA_{a2}) + \cdots + (EA_{ay} \times PA_{ay}) \quad (1)$$

Where:[14]

$$PA_{a1} = \frac{Area_{a1}}{(Area_{a1} + Area_{a2} + \cdots + Area_{ay})}$$

$$PA_{a2} = \frac{Area_{a2}}{(Area_{a1} + Area_{a2} + \cdots + Area_{ay})}$$

$$PA_{ay} = \frac{Area_{ay}}{(Area_{a1} + Area_{a2} + \cdots + Area_{ay})}$$

And:

AR_r	=	Weighted average adoption rate in the region r (%)
EA_{ay}	=	Existing adoption rate of proposed project activity *ay* in the region (%)
PA_{ay}	=	Ratio of proposed project-level adoption of activity *ay* relative to proposed project-level adoption of all activities in the region
$Area_{ay}$	=	Area of proposed project-level adoption of activity *ay* in the region (hectares)
ay	=	1, …, *ay* project activities ranked by area covered in the region, where 1 = largest area covered

A project proponent may include areas where more than one optional project activity will be implemented on the same land (e.g., furrow irrigation plus avoided burning of rice residues). Evidence of existing adoption rates for the combined (two or more) activities should be used to calculate the weighted mean adoption rate of the proposed combined activities. Where evidence on existing adoption rates for the combined activities is not available, the project proponent may multiply the existing adoption rates (i.e., pre-project) of the individual activities to estimate the combined activity adoption rate. For example, with a statewide existing adoption rate of 40% for furrow irrigation and 10% for avoided burning, the adoption rate to be applied in Equation (1) for lands combining (stacking) these two activities would be 4% (i.e., 0.4 × 0.1 = 0.04).

Where Steps 1–3 of additionality analysis are satisfied, the proposed project activity is additional.

[14] Parameters are described below equations only at their first appearance.

8 QUANTIFICATION OF ESTIMATED GHG EMISSION REDUCTIONS

8.1 Summary

This methodology provides a flexible approach to quantifying GHG emission reductions and carbon dioxide removals from the adoption of improved management practices in paddy rice production in the project compared to the baseline scenario. Baseline and project emissions are defined in terms of flux of CH_4, N_2O, and CO_2 in tonnes of CO_2e per unit area per monitoring period. Within each quantification unit, stock changes in each included pool and source are treated on a per unit basis. Where a monitoring period spans multiple calendar years, the equations quantify reductions by year to appropriately define vintage periods.

The approaches for quantifying CO_2, CH_4, and N_2O emissions are listed in Table 4. Where more than one quantification approach is allowable for a given GHG and emission source, more than one approach may be used provided that the same approach is used for a given quantification unit in both the project and baseline scenarios.

Table 4: Summary of quantification approaches

GHG	Source	Quantification Approach 1: Model	Quantification Approach 2: Direct Measurement	Quantification Approach 3: Default Emission Factors	
				Global/National	Sub-national
CO_2	SOC[15]	X			
CO_2	Fossil fuels			X	X
CO_2	Liming			X	
CH_4	Soil methanogenesis	X	X	X	X
CH_4, N_2O	Biomass burning			X	X
N_2O	Use of nitrogen fertilizers and nitrogen from rice straw	X		X	X
Project Scale		Any	Any	Small	Any

[15] Where Quantification Approach 1 is used, the SOC pool must be modeled.

For each pool/source, subdivisions of the project area that use different quantification approaches must be accounted separately.

A project proponent may switch between allowable quantification approaches for a given GHG source during the project crediting period, provided that the same approach is used for both the project and baseline scenarios. The quantification approaches are as follows.

Quantification Approach 1: Modeling

An acceptable model[16] is used to estimate GHG flux based on soil characteristics, implemented rice production practices, initial SOC stocks, and climatic conditions in homogenous quantification units. All modeling must be undertaken in accordance with the requirements and procedures in *VM0042* (refer to Table 8, Section 8.3) and *VMD0053*. Where the project involves the introduction of a new cultivar with a materially different root biomass to the cultivar(s) used in the baseline, it must be demonstrated that the model domain sufficiently covers such changes. It must also be demonstrated that the model domain sufficiently covers any potential changes in N_2O flux associated with the implementation of project activities including changes in irrigation, fertilization events, and changes in biomass to soils. Projects using QA1 must take initial measures of SOC at the project start for use within the model.[17]

Project proponents opting to use QA1 may choose between using a Process-Based Model or a Surrogate Process Model. Evaluation and approval of Process-Based Models and Surrogate Process Models must follow procedures for calibration, validation and uncertainty quantification of process models as described in VMD0053. If Surrogate Process Models are used, they must follow additional guidance in Appendix 3.

Quantification Approach 2: Direct Measurement

Direct measurement is used to quantify flux in CH_4 emissions for both baseline and project conditions. This approach is relevant where models are unavailable or have not yet been statistically validated or parameterized, or where project proponents prefer to use a direct measurement approach. The baseline scenario is measured and remeasured directly at a baseline control site linked to one or more quantification units. Requirements for directly measuring CH_4 are outlined in Section 9.1.

Flux in all other trace GHGs (such as N_2O from soils, CO_2 from energy usage, and combustion emissions related to avoided biomass burning) must be accounted for using the default emission factor approach.

Quantification Approach 3: Default Emission Factors (Global/Regional/National/Sub-national)

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[16] The requirements for selecting an acceptable model are detailed in the VCS Methodology Requirements, Section 2.5.1.

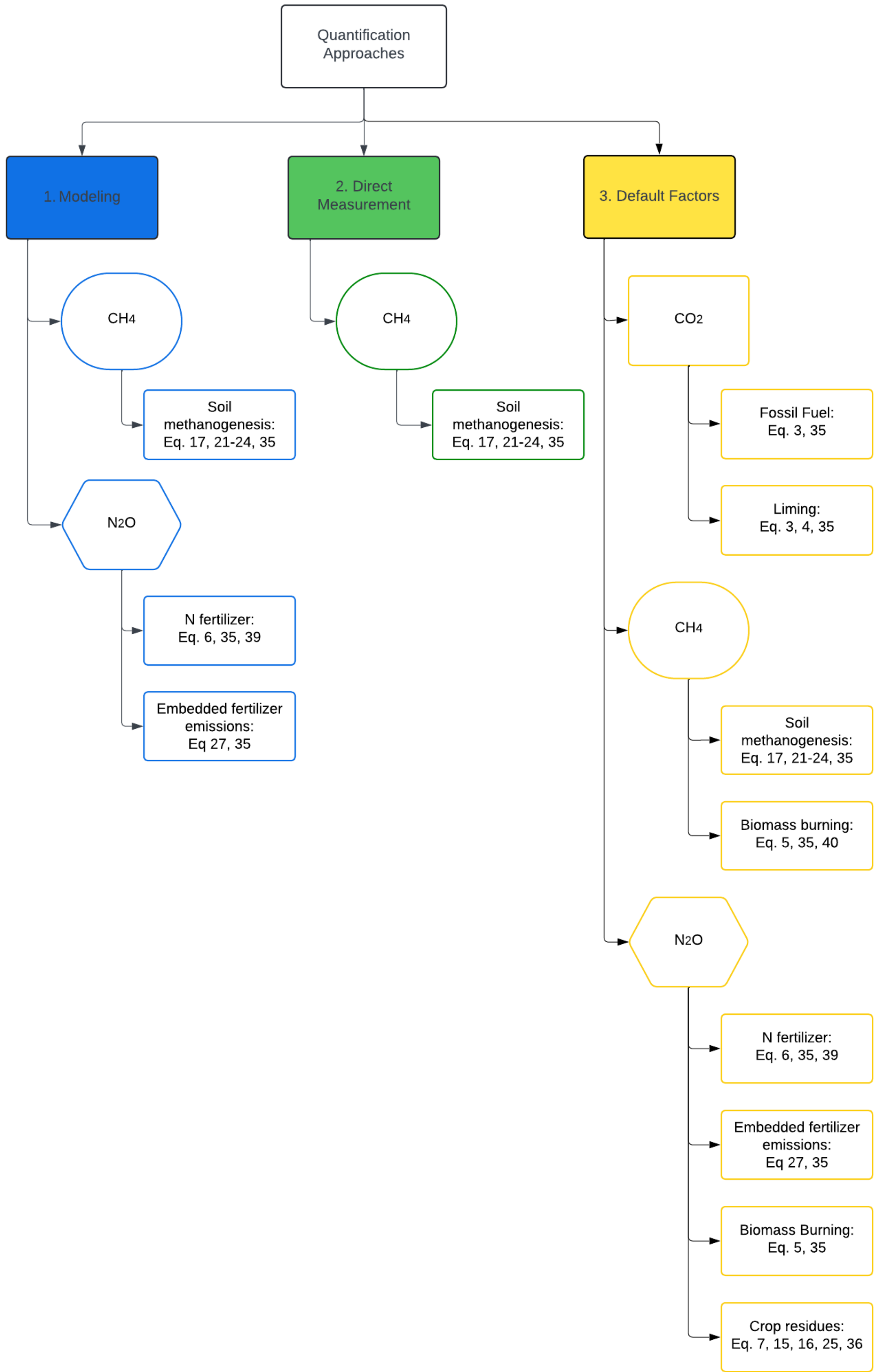
[17] Initial measurements of SOC may be conducted at $t = 0$ or (back-) modeled to $t = 0$ from measurements collected within ± 5 years of $t = 0$. The soil sampling requirements and procedures shall be following the guidance in VM0042 Section 8.2.1 and VMD0053.

Flux in CH_4, N_2O, and CO_2 (from energy usage) is calculated following the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories* using equations and guidance contained in this methodology. Emission factors for nitrification inhibitors, enhanced efficiency fertilizers, and methanotrophs may be derived from literature (see Section 8.3 for further guidance). Where default emission factors are not available for a practice that has been implemented on a given quantification unit (e.g., for practices such as nitrification inhibitors or methanotrophs), one of the other quantification approaches must be used.

Simplified global and national emission factors for CH_4 from soils may only be used by small-scale projects. Sub-national emission factors for CH_4 from soils, N_2O, and CO_2 from energy usage may be used by projects of any size.

Where the project involves the introduction of a new cultivar with a materially different root biomass to the cultivar(s) used in the baseline, the project must account for the changes in biomass to soil (via changes to the *ROA* parameter in Equation (19).

Figure 1: Equation map of this methodology



8.2 Baseline Emissions

A project proponent may switch between allowable quantification approaches for a given GHG source during the project crediting period, provided that the same approach is used for both the project and baseline scenarios. Baseline quantification must be undertaken following the guidance below and in the following subsections.

Quantification Approach 1: Modeling

Under Quantification Approach 1, an acceptable model is used to estimate GHG flux based on soil characteristics, implemented rice production practices, initial SOC stocks, and climatic conditions in homogenous quantification units. All modeling must be undertaken in accordance with the requirements in VM0042 (refer to Table 8, Section 8.3) and VMD0053.

Project proponents should ensure their model is appropriately calibrated and validated for their given project domain, including any new cultivars, changes in N_2O flux and activities such as methanotrophs and nitrification inhibitors.

Quantification Approach 2: Direct Measurement

Under Quantification Approach 2, direct measurement is used to quantify flux in CH_4 emissions for both baseline and project conditions. Projects must use baseline control sites linked to one or more quantification units to derive requisite data. Requirements for stratification for baseline control sites are available in Section 6, and guidance on directly measuring CH_4 are outlined in Section 9.1. Flux in all other trace GHGs (such as N_2O from soils, CO_2 from energy usage, and combustion emissions related to avoided biomass burning) must be accounted for using the default emission factor approach.

Quantification Approach 3: Default Emission Factors (Global/Regional/National/Sub-national)

Under Quantification Approach 3, flux in CH_4, N_2O, and CO_2 (from energy usage) are calculated using default emission factors and equations, and following guidance contained in this section. Emission factors for nitrification inhibitors, enhanced efficiency fertilizers, and methanotrophs may be derived from literature (see Section 8.3 for further guidance). Where default emission factors are not available for a practice that has been implemented on a given quantification unit (e.g., for practices such as nitrification inhibitors or methanotrophs), one of the other quantification approaches must be used.

8.2.1 Carbon Dioxide Emissions from Fossil Fuel Combustion

This section must be used to quantify any flux in CO_2 emissions from fossil fuel usage, regardless of which quantification approach is used. Where CO_2 emissions from fossil fuel are included in the project boundary per Table 2, they are quantified in the baseline scenario under all quantification approaches using Equations (2 and (3 below.

$$\overline{CO_2\_ff_{bsl,i,t}} = (\sum_{j=1}^{J} EFF_{bsl,j,i,t})/A_i \qquad (2)$$

Where:

$\overline{CO_2\_ff_{bsl,i,t}}$	=	Areal mean carbon dioxide emissions from fossil fuel combustion in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)
$EFF_{bsl,j,i,t}$	=	Carbon dioxide emissions from combustion of fossil fuel type *j* in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)
A_i	=	Area of quantification unit *i* (ha)
j	=	Type of fossil fuel (gasoline or diesel)

The parameter $EFF_{bsl,j,i,t}$ is estimated using the following equation:

$$EFF_{bsl,j,i,t} = FFC_{bsl,j,i,t} \times EF_{CO2,j} \qquad (3)$$

Where:

$FFC_{bsl,j,i,t}$	=	Consumption of fossil fuel type *j* for quantification unit *i* in year *t* (liters)
$EF_{CO2,j}$	=	Emission factor for combustion of fossil fuel type *j* (t CO_2e/liter)

8.2.2 Carbon Dioxide Emissions from Liming

This section must be used to quantify any flux in CO_2 emissions from liming when using Quantification Approaches 2 and 3, Under Quantification Approach 1, project must follow the guidance in this section if the chosen model does not include estimations of emissions from liming.

Application of calcitic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$) releases bicarbonate ($2HCO_3^-$), which evolves into CO_2 and water (H_2O) as carbonate limes dissolve. Where one of the rice production practices is liming and resulting CO_2 emissions are not deemed de minimis, they are quantified in the baseline scenario under Quantification Approaches 2 and 3 using Equations (4 and (5.

Parameter $\overline{CO2\_lime_{bsl,i,t}}$ is estimated using the following equation:

$$\overline{CO2\_lime_{bsl,i,t}} = EL_{bsl,i,t}\ /A_i \qquad (4)$$

Where:

$\overline{CO2\_lime_{bsl,i,t}}$	=	Areal mean carbon dioxide emissions from liming in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)
$EL_{bsl,i,t}$	=	Carbon dioxide emissions from liming in the baseline scenario for quantification unit *i* in year *t* (t CO_2e)

$$EL_{bsl,i,t} = \left((M_{limestone,bsl,i,t} \times EF_{limestone}) + (M_{dolomite,bsl,i,t} \times EF_{dolomite})\right) \times \frac{44}{12} \quad (5)$$

Where:

$M_{limestone,bsl,i,t}$	=	Amount of calcitic limestone ($CaCO_3$) applied to quantification unit *i* in year *t* in the baseline (tonnes)
$EF_{Limestone}$	=	Emission factor for calcitic limestone (0.12) (t C/t limestone)
$M_{Dolomite,bsl,i,t}$	=	Amount of dolomite ($CaMg(CO_3)_2$) applied to quantification unit *i* in year *t* (tonnes)
$EF_{Dolomite}$	=	Emission factor for dolomite (0.13) (t C/t dolomite)
44/12	=	Molar mass ratio of CO_2 to C applied to convert CO_2-C emissions to CO_2 emissions

8.2.3 Methane or Nitrous Oxide Emissions from Biomass Burning

This section must be used to quantify any flux in CH_4 and N_2O emissions from avoided biomass burning, regardless of which quantification approach is used.

Where CH_4 and N_2O emissions from biomass burning are included in the project boundary per Table 2, they are quantified in the baseline scenario under all quantification approaches using Equation (6 for their respective denotations (CH_4 or N_2O).

$$\overline{CH4 \text{ or } N2O\_bb_{bsl,i,t}} = \left(\frac{GWP_{CH4 \text{ or } N2O} \times \sum_{c=1}^{C} MB_{bsl,c,i,t} \times CF_c \times EF_{c,CH4 \text{ or } N2O}}{10^6}\right)/A_i \quad (6)$$

Where:

$\overline{CH4\_bb_{bsl,i,t}}$	=	Methane emissions in the baseline scenario from biomass burning for quantification unit *i* in year *t* (t CO_2e/ha)
$\overline{N2O\_bb_{bsl,i,t}}$		Nitrous oxide emissions in the baseline scenario from biomass burning for quantification unit *i* in year *t* (t CO_2e/ha)
GWP_{CH4}	=	Global warming potential for methane (t CO_2e/t CH_4)
GWP_{N2O}	=	Global warming potential for nitrous oxide (t CO_2e/t N_2O)
$MB_{bsl,c,i,t}$	=	Mass of agricultural residues of type *c* (i.e., rice straw) burned in the baseline scenario for quantification unit *i* in year *t* (kg)
CF_c	=	Combustion factor for agricultural residue type *c* (proportion of pre-fire fuel biomass consumed)

$EF_{c,CH4}$	=	Methane emission factor for the burning of agricultural residue type *c* (g CH_4/kg dry matter burned)
$EF_{c,N2O}$		Nitrous oxide emission factor for the burning of agricultural residue type *c* (g N_2O/kg dry matter burned)
c	=	Type of agricultural residue
10^6	=	Conversion factor from grams to tonnes

8.2.4 Nitrous Oxide Emissions from Nitrogen Fertilizers

This section must be used to quantify any flux in N_2O emissions from the use of nitrogen fertilizers as well as nitrogen derived from rice straw incorporated into soils when using Quantification Approach 2 and 3, Equations (8)-(14) is used. Under Quantification Approach 1, project must follow the guidance in this section if the chosen model does not include estimations of emissions from fertilizers, or any nitrous oxide reducing amendments that are used. Under Quamtification Approach 1, Equation (7) is used.

Nitrous oxide emissions due to nitrification/denitrification include direct and indirect emissions from nitrogen fertilizers and direct emissions from nitrogen derived from rice straw. Where N_2O emissions due to nitrogen inputs to soils from nitrogen fertilizers and rice straw are included in the project boundary per Table 2, they are quantified in the baseline scenario using the equations below.

Quantification Approach 1

In Quantification Approach 1, direct and indirect N_2O emissions due to nitrogen inputs to soils (nitrogen fertilizers) in the baseline scenario are quantified as:

$$\overline{N2O\_soil_{bsl,i,t}} = GWP_{N2O} \times f\left(N2O\_soil_{bsl,i,t}\right) \quad (7)$$

Where:

$\overline{N2O\_soil_{bsl,i,t}}$	=	Areal mean direct and indirect nitrous oxide emissions due to nitrogen inputs to soils in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)
$f(N2O\_soil_{bsl,i,t})$	=	Modeled nitrous oxide emissions from soil in the baseline scenario for quantification unit *i* in year *t*, calculated by modeling soil fluxes of nitrogen forms over the course of the preceding year (t N_2O/ha)
GWP_{N2O}	=	Global warming potential for nitrous oxide (t CO_2e/t N_2O)

Quantification Approach 3

In Quantification Approach 3, N_2O emissions due to nitrogen inputs to soils in the baseline scenario are estimated by applying Equations (8) **Error! Reference source not found.**–(14).

Where N_2O emissions due to fertilizer use are included in the project boundary per Table 2, they are quantified in the baseline scenario using Equations (88)–(14).

$$N2O\_fert_{bsl,i,t} = N2O\_fert_{bsl,direct,i,t} + N2O\_fert_{bsl,indirect,i,t} \tag{8}$$

Where:

$N2O\_fert_{bsl,direct,i,t}$	=	Direct nitrous oxide emissions due to fertilizer use in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)
$N2O\_fert_{bsl,indirect,i,t}$	=	Indirect nitrous oxide emissions due to fertilizer use in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)

Direct N_2O emissions due to fertilizer use in the baseline scenario are quantified in Equations (9)–(11.

$$\overline{N2O\_fert_{bsl,direct,i,t}} = \left(FSN_{bsl,i,t} + FON_{bsl,i,t}\right) \times EF_{Ndirect} \times \frac{44}{28} \times GWP_{N2O}/A_i \tag{9}$$

$$FSN_{bsl,i,t} = \sum_{SF} M_{bsl,SF,i,t} \times NC_{SF} \tag{10}$$

$$FON_{bsl,i,t} = \sum_{OF} M_{bsl,OF,i,t} \times NC_{OF} \tag{11}$$

Where:

$\overline{N2O\_fert_{bsl,direct,i,t}}$	=	Areal mean direct nitrous oxide emissions due to fertilizer use in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)
$FSN_{bsl,i,t}$	=	Total nitrogen applied to quantification unit *i* in year *t* as synthetic N fertilizer in the baseline scenario (t N)
$FON_{bsl,i,t}$	=	Total nitrogen applied to quantification unit *i* in year *t* as organic N fertilizer in the baseline scenario (t N)
$EF_{Ndirect}$	=	Emission factor for nitrous oxide emissions from N additions from synthetic fertilizers,[18] organic amendments, and crop residues (t N_2O-N/t N applied)

[18] Where nitrification inhibitors or other amendments (i.e., slow release) that reduce N_2O emissions from soils are used, project proponents may use a peer-reviewed emission factor to estimate N_2O emissions, pursuant to the guidance in Section 8.3 for Quantification Approach 3.

$M_{bsl,SF,i,t}$	=	Mass of N-containing synthetic fertilizer type *SF* applied to quantification unit *i* in year *t* in the baseline scenario (tonnes)
NC_{SF}	=	N content of synthetic fertilizer type *SF* (t N/t fertilizer)
$M_{bsl,OF,i,t}$	=	Mass of N-containing organic fertilizer type *OF* applied to quantification unit *i* in year *t* in the baseline scenario (t fertilizer)
NC_{OF}	=	N content of organic fertilizer type *OF* (t N/t fertilizer)
SF	=	Synthetic N fertilizer type
OF	=	Organic N fertilizer type
44/28	=	Molar mass ratio of N_2O to N applied to convert N_2O-N emissions to N_2O emissions

Indirect N_2O emissions due to fertilizer use in the baseline scenario are quantified in Equations (12)–(14).

$$\overline{N2O\_fert_{bsl,indirect,i,t}} = (N2O\_fert_{bsl,volat,i,t} + N2O\_fert_{bsl,leach,i,t})/A_i \tag{12}$$

$$N2O\_fert_{bsl,volat,i,t} = \begin{bmatrix} (FSN_{bsl,i,t} \times Frac_{GASF,l,S}) + \\ (FON_{bsl,i,t} \times Frac_{GASM,l,S}) \end{bmatrix} \times EF_{Nvolat} \times \frac{44}{28} \times GWP_{N2O} \tag{13}$$

$$N2O\_fert_{bsl,leach,i,t} = \begin{pmatrix} FSN_{bsl,i,t} + \\ FON_{bsl,i,t} \end{pmatrix} \times Frac_{LEACH,l,S} \times EF_{Nleach} \times \frac{44}{28} \times GWP_{N2O} \tag{14}$$

Where:

$\overline{N2O\_fert_{bsl,indirect,i,t}}$	=	Areal mean indirect nitrous oxide emissions due to fertilizer use in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)
$N2O\_fert_{bsl,volat,i,t}$	=	Indirect nitrous oxide emissions produced from atmospheric deposition of N volatilized due to fertilizer use in the baseline scenario in quantification unit *i* in year *t* (t CO_2e)
$N2O\_fert_{bsl,leach,i,t}$	=	Indirect nitrous oxide emissions produced from leaching and runoff of N, in regions where leaching and runoff occurs, due to fertilizer use in the baseline scenario in quantification unit *i* in year *t* (t CO_2e)
$Frac_{GASF,l,S}$	=	Fraction of all synthetic N added to soils that volatilizes as NH_3 and NO_x for manure management system *S* and livestock type *l* (dimensionless)
$Frac_{GASM,l,S}$	=	Fraction of all organic N added to soils and N in manure applied to soils that volatilizes as NH_3 and NO_x for manure management system *S* and livestock type *l* (dimensionless)
EF_{Nvolat}	=	Emission factor for nitrous oxide emissions from atmospheric deposition of N on soils and water surfaces (t N_2O-N/(t NH_3-N + NO_x-N volatilized))

$Frac_{LEACH,l,S}$	=	Fraction of N (synthetic or organic) added to soils that is lost through leaching and runoff, in regions where leaching and runoff occurs, for manure management system S and livestock type *l* (dimensionless)
EF_{Nleach}	=	Emission factor for nitrous oxide emissions from leaching and runoff (t N_2O-N/t N leached and runoff)

Where N_2O emissions due to crop residues are present, they are quantified in the baseline scenario using Equations (15) and (16).

$$\overline{N2O\_Nstraw_{bsl,i,t}} = (F_{CR,bsl,i,t} \times EF_{Ndirect} \times \frac{44}{28} \times GWP_{N2O})/A_i \quad (15)$$

Where:

$\overline{N2O\_Nstraw_{bsl,i,t}}$	=	Areal mean nitrous oxide emissions from rice straw in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)
$F_{CR,bsl,i,t}$	=	Amount of N in rice straw (above- and belowground) returned to soils in the baseline scenario for quantification unit *i* in year *t* (t N)

$$F_{CR,bsl,i,t} = MB_{bsl,i,t} \times N_{content} \quad (16)$$

Where:

$MB_{bsl,i,t}$	=	Annual dry matter (above- and belowground) of rice straw returned to soils for quantification unit *i* in year *t* in the baseline (t dry matter)
$N_{content}$	=	Fraction of N in dry matter for rice straw (t N/t dry matter)

8.2.5 Methane Emissions from Soils

This section must be used to quantify flux in CH_4 emissions from soils when using any quantification approach.

Quantification Approach 1: Modeling

$$\overline{CH4\_soil_{bsl,i,t}} = GWP_{\mathrm{CH4}} \times ʄ(CH4\_soil_{bsl,i,t}) \quad (17)$$

Where:

$\overline{CH4\_soil_{bsl,i,t}}$	=	Areal mean methane emissions from soil in the baseline scenario for quantification unit *i* in year *t* (t CO_2e/ha)
$ʄ(CH4\_soil_{bsl,i,t})$	=	Modeled methane emissions from soil in the baseline scenario for quantification unit *i* in year *t*, calculated by modeling soil methane fluxes over the course of the preceding year (t CO_2e/ha)

Quantification Approach 2: Direct Measurement

For projects using Quantification Approach 2, the values in Equation (17) for $\overline{CH4\_soil_{bsl,i,t}}$ must be set using Section 8.2.6.

Quantification Approach 3: Default Factors (Global/Regional/National/Subnational)

For projects using Quantification Approach 3, the values in Equation (17 for $\overline{CH4\_soil_{bsl,i,t}}$ must be set using Section be calculated using Equations (18)–(19.

Where amendments that reduce CH_4 emissions from soils are used, project proponents may use a peer-reviewed emission factor to estimate CH_4 emissions, pursuant to the guidance in Section 8.3 for Quantification Approach 3.

$$EF_{bsl,i,t} = EF_{bsl,c} \times SF_{bsl,w} \times SF_{bsl,p} \times SF_{bsl,o} \quad (18)$$

Where:

$EF_{bsl,i,t}$	=	Baseline methane emission factor for continuously flooded fields without organic amendments for quantification unit *i* in year *t* (kg CH_4/ha/day)
$EF_{bsl,c}$	=	Baseline methane emission factor for continuously flooded fields without organic amendments (kg CH_4/ha/day)[19]
$SF_{bsl,w}$	=	Baseline scaling factor to account for differences in water regime during the cultivation period; scaling factors must be sourced from Table 5.12 (Updated) in Chapter 5 of the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*
$SF_{bsl,p}$	=	Baseline scaling factor to account for differences in water regime in the pre-season before the cultivation period; scaling factors must be sourced from Table 5.13 (Updated) in Chapter 5 of the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*
$SF_{bsl,o}$	=	Baseline scaling factor to account for organic amendments, set using Equation (19) below

$$SF_{bsl,o} = \left(1 + \sum_{i} ROA_a \times CFOA_a\right)^{0.59} \quad (19)$$

[19] Projects with dynamic baseline activities must use the most conservative baseline assumption from a three-year historical look-back period, following the guidance in Section 6, above Table 3. This may mean that a project must set $EF_{bsl,c}$ using the emission factor for single drainage.

Where:

ROA_a	=	Application rate of organic amendment type *a*, in dry weight for straw and fresh weight for others (t/ha)[20]
$CFOA_a$	=	Conversion factor for organic amendment type *a;* conversion factors must be sourced from Table 5.14 (Updated) in Chapter 5 of the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*

$$BE_{CH4,i,t} = EF_{bsl,i,t} \times L_t \times 10^{-3} \times GWP_{CH4} \tag{20}$$

Where:

$BE_{CH4,i,t}$	=	Baseline emissions of methane from soils, for quantification unit *i* in year *t* (t CO_2e)
$EF_{bsl,i,t}$	=	Daily emission factor, for quantification unit *i* in year *t* (kgCH_4/day)
L_t	=	Cultivation period of rice in year *t* (days)[21]

8.2.6 Direct Measurement of Methane Emissions

The direct measurement of methane emissions is to be undertaken using chamber measurements pursuant to the requirements and guidance in Section 9.1, and following the guidance in this section.

Average emission factors must be derived using linear regression of the direct measurements, following the equations below. Such analysis must be repeated separately for baseline and project fields. For each gas analysis, calculate the mass of CH_4 emissions using the equations in this section.

$$m_{CH4,pt} = Conc_{CH4,pt} \times Vol_{Ch} \times M_{CH4} \times \frac{1\ atm}{R \times T_{pt} \times 1000} \tag{21}$$

Where:

$m_{CH4,pt}$	=	Mass of methane in chamber at time *pt* (mg)
pt	=	Point of time at which sample is taken (e.g., 0, 15, 30 in case of three samples within 30 minutes)
$Conc_{CH4,pt}$	=	Methane concentration in chamber at time *pt* (ppm)

[20] For the baseline, 5 t/ha of straw is assumed. This should be adjusted where material changes in biomass management occur in the project, such as increased biomass to soils.
[21] Each cultivation period commences at land preparation and continues until harvest or post-season drainage.

Vol_{Ch}	=	Chamber volume (liters)
M_{CH4}	=	Molar mass of methane: 16 (g/mol)
1 atm	=	Assume constant pressure of 1 atm, unless pressure measurement equipment is installed
R	=	Universal gas constant: 0.08206 (liters atm/K/mol)
T_{pt}	=	Temperature at time *pt* (K)

Determine the slope of the line of best fit for describing the relationship between $m_{CH4,pt}$ and *pt* using Equation (22).

$$sl = \frac{\Delta m_{CH4}}{\Delta pt} \tag{22}$$

Where:

sl	=	Slope of line of best fit (mg/min)

The hourly emission rate must be calculated for each chamber measurement:

$$RE_{ch} = sl \times \frac{60min}{A_{Ch}} \tag{23}$$

Where:

RE_{ch}	=	Emission rate of chamber *ch* (mg/h/m^2)
ch	=	Index for replicate chamber on a plot
A_{ch}	=	Chamber area (m^2)

Calculate the average emission rate of a chamber measurement per plot:

$$RE_{plot} = sl \times \frac{\sum_{ch=1}^{Nch} RE_{ch}}{Nch} \tag{24}$$

Where:

RE_{plot}	=	Average emission rate per plot (mg/h/m^2)
Nch	=	Number of chamber measurements per plot

Once an average emission rate has been calculated for each chamber measurement, a seasonal emission factor must be calculated. The seasonal emission rate is calculated by multiplying the average emission rate for each chamber measurement with the number of hours in the measurement interval (e.g., one week = 168 hours) and accumulating the results of every measurement interval over the season. Convert from mg/m^2 to kg/ha by multiplying by

0.01. A separate seasonal emission factor must be calculated for each distinct season in a double cropping system. Project proponents may optionally calculate an annual emission factor across both seasons in a double cropping system, provided the same approach is used for both seasons. Where using a single season emission factor in double cropping systems, the emission factor must only be used for the corresponding season (e.g., the first season emission factor must not be used for second season rice cultivation).

8.3 Project Emissions

Emissions resulting from monitoring period rice cultivation activities are calculated or modeled based on monitored inputs. Emissions of CO_2, CH_4, and N_2O during the monitoring period must be quantified following the approaches found in Table 4 and using the equations provided in Section **Error! Reference source not found.**. For all equations, the subscript *bsl* must be substituted with *mp* to indicate that the relevant values are being calculated for the monitoring period.

In addition to the above, there are three calculations that this methodology prescribes separately for project emissions, which are not undertaken for baseline emissions:

1) All fields that employ reductions in rice straw burning must account for emissions associated with the alternative fate of the rice straw (using Equation (25 below).
2) All fields that employ changes in irrigation must account for N_2O emissions associated with such changes by applying an N_2O correction factor (using Equation (26 below).
3) Project proponents may optionally choose to account for a reduction in emissions embedded in fertilizer production, which would be lower in the monitoring period, due to reductions in the total amount of nitrogen used by the project (using Equation (27 below).

Quantification Approach 1: Modeling

Model inputs must be collected following the guidance in *VM0042* Table 8 (Section 8.3). As set out in Table 4 of this methodology, Quantification Approach 1 is applicable only to fluxes of SOC, and of CH_4 and N_2O.

Quantification Approach 2: Direct Measurement

Quantification Approach 2 is used to estimate CH_4 emissions, following the guidance in Section 9.1. As set out in Table 4, Quantification Approach 2 is applicable only to fluxes of CH_4 from soil methanogenesis.

Quantification Approach 3: Default Factors (Global/Regional/National/Subnational)

As set out in Table 4, Quantification Approach 3 is applicable for all GHG fluxes except SOC.

Project emissions are calculated for each sample field using applicable default values and any monitored parameters. The most accurate available emission factor applicable to the project conditions must be used from the following:

1) An emission factor for CH4 emissions derived using Quantification Approach 2, following the guidance in Section 9.1.

2) Tier 1 and Tier 1a emission factors from the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*

3) Where available, a project-specific emission factor from a peer-reviewed scientific publication[22]

4) An emission factor derived using peer-reviewed scientific literature following the guidance to derive Tier 2 emission factors in the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*.

5) Where there is no relevant peer-reviewed scientific literature, the project proponent may propose alternative sources of information (e.g., government databases, industry publications) to establish the default factor(s) and must provide evidence that the alternative source of information is robust and credible (e.g., independent expert attestation). This approach must not be used for CH_4 and N_2O from soils.

8.3.1 Project Emissions from Diverting Rice Straw to Alternative End-Uses

Where a project materially reduces the amount of rice straw burned, Equation (25) must be used to account for project emissions associated with alternative end-uses of the rice straw.

$$PE_{AB,t} = (RS_{removed,r} \times EF_{eu,r} \times 0.001) \quad (25)$$

Where:

$PE_{AB,t}$	=	Project emissions from diverting rice straw to alternative off-farm end uses in year *t* (t CO_2e)
$EF_{eu,r}$	=	Emission factor for off-farm end use category s (see Table 5) (kg CO_2e/t dry straw)
$RS_{removed,r}$	=	Mass of rice straw removed from field and sent to end use category *s* (t dry rice straw)
0.001	=	Unit conversion from kilogram to tonne

[22] As stated in Section 2.5 of the *VCS Methodology Requirements, v4.4* (or equivalent section of the most recent version), peer-reviewed scientific literature used to derive (default) emission factors must be in a journal indexed in the Web of Science: Science Citation Index.

Table 5: Emission factors for end use of crop residue diverted from burning or field incorporation

End use	Emission Source	Emission Factor (kg CO_2e/t dry straw)	Rationale
Animal feed	Enteric CH_4 and N_2O from manure deposition from livestock[23]	Calculated using *VM0042* Sections 8.2.7 and 8.2.10	Equations to account for enteric CH_4 and N_2O emissions associated with manure deposition
Animal bedding	Avoiding post-harvest chopping and disking	0	Post-harvest chopping and disking is typically associated with rice straw burning. Using rice straw for animal bedding is estimated to result in a decline in CO_2 emissions (−11.63 kg CO_2e/t rice straw) associated with avoided post-harvest chopping and disking.[24] It is therefore conservative to not credit for such emission reductions, and unnecessary to apply a deduction for such activities.
Used offsite as erosion control	Avoiding post-harvest chopping and disking	−11.63	Using rice straw offsite as erosion control results in additional CO_2 emissions from on-farm management activities, and downstream activities.
	Swathing, raking, baling	23.25	
	Road siding, storing, loading, transport	69.76	
	Spreading	11.63	
	TOTAL	93.01	
Biochar	Crop residues, rice straw	0	The production of biochar from rice straw is a carbon sink. Diverting rice straw to such end-uses without being credited under this methodology is therefore conservative.

[23] Adapted from Table 10.10, in the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories* Volume 4, Agriculture, Forestry and Other Land Use.
[24] Adapted using US EPA emission factors for greenhouse gas inventories from Mutters et al. (2007).

End use	Emission Source	Emission Factor (kg CO_2e/t dry straw)	Rationale
Renewable fuel production	Crop residues, rice straw	0	Bioenergy production from rice straw reduces emissions in the range of 1.79 to 14 375 kt CO_2e (Alengebawy et al., 2022). Diverting rice straw to such end-uses without being credited under this methodology is therefore conservative.
Particleboard	Crop residues, rice straw	0	The emissions impact of reusing rice straw to produce particleboard is significantly reduced by 6–10% compared to using wood resources (Shang et al., 2020). Diverting rice straw to such end-uses without being credited under this methodology is therefore conservative.

8.3.2 Project Emissions from N_2O Due to Irrigation Change

All fields that employ changes in irrigation must account for N_2O emissions associated with such changes by applying an N_2O correction factor, regardless of whether there are any changes in the volume of nitrogen applied.

$$PE_{Red-Irri,t} = \sum_{s}^{S} \left(Q_{N,s} \times A_s\right) \times CF_{N2O} \times 10^{-3} \times GWP_{N2O} \quad (26)$$

Where:

$PE_{Red\text{-}Irri,t}$	=	Deduction to account for flux in N_2O emissions due to period of drying on rice fields in year *t* (t CO_2e)
$Q_{N,s}$	=	Application rate of N input in the monitoring period (kg N input/ha)
CF_{N2O}	=	N_2O correction factor for calculating N_2O emissions flux due to period of drying on rice fields; value of 0.00314 kg N_2O/kg N-input must be used[25]
A_s	=	Area of project fields where the application rate of N input in the project does not exceed that of the baseline in each quantification unit *s* in year (ha)
s	=	Quantification unit (ha)

[25] The correction factor has been derived from the emission factors (kg N_2O-N/t N) from Table 11.1 (Updated), Chapter 11, Volume 4, in the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. The difference between the aggregated default value emission factors for continuously flooded rice fields and rice fields with single or multiple drainage was converted from N_2O-N into N_2O emissions. See Appendix 3 for further details.

8.3.3 Project Emissions from Reductions in Embedded Fertilizer Emissions

Where projects materially reduce the total nitrogen applied to soils (see Section 8.2.4), project proponents may optionally choose to account for a reduction in emissions embedded in fertilizer production.

Project proponents may estimate the emission reductions associated with upstream imbedded emissions using evidence including peer reviewed literature, government records, production facility records, survey data, publicly available LCA databases, or reports compiled by industry associations.

Pursuant to Section 3.8.5 of the *VCS Methodology Requirements, v4.4*, project proponents must assess the rate of displacement using evidence including peer reviewed literature, government records, production facility records, survey data, or reports compiled by industry associations.

Project proponents must use Equation (27) to calculate the reduction in embedded fertilizer emissions associated with the reduction in total fertilizers used by the project.

$$N2O\_fert_{LCA} = \sum_{SF} EF_{fert_{LCA,SF}} \times N_{red_{total,i,t}} \tag{27}$$

Where:

$N2O\_fert_{LCA}$	=	Embedded emissions avoided due to reduction in fertilizer use in the monitoring period (t CO_2e)
$EF_{fert\_LCA,SF}$	=	Emission factor for embedded emissions associated with fertilizer production for synthetic fertilizer type *SF* (t CO_2e/t fertilizer)
$N_{red\_total,i,t}$	=	Total reduction in nitrogen fertilizers in the monitoring period, relative to the baseline for quantification unit *i* in year *t* (t fertilizer)

8.4 Leakage Emissions

Improved rice production projects may result in leakage through new application of organic amendments from outside the project area (i.e., organic amendments applied in the project from outside of the project area that were not previously applied in the historical look-back period); declines in rice yield; and/or diversion of biomass residues that were used for bioenergy applications in the baseline scenario. Guidance on how to account for each type of leakage is provided below.

Where the sum of increases in GHG emissions from any leakage source is less than 5% of the total net anthropogenic reductions and removals due to the project, such sources may be deemed de minimis and may be ignored. This demonstration must be conducted via application of the CDM *Tool for testing significance of GHG emissions in A/R CDM project activities.*

8.4.1 Leakage from New Application of Organic Amendments from Outside the Project Area

Where new manure, compost, or biosolids are applied in the project that were not applied in the historical look-back period, there is a risk of activity-shifting leakage. To account for this type of leakage, a deduction must be used unless any of the following apply:

1) The manure or compost applied in the project is produced on-site from farms within the project area;
2) The manure is documented to have been diverted from an uncontrolled anaerobic lagoon, pond, tank, or pit from which there is no recovery of CH_4 for generation of heat and/or electricity; or
3) The manure, compost, or biosolids are documented to not have been used as a soil amendment.

The deduction represents the portion of manure, compost, or biosolids carbon that remains in the project area without degrading and which would have otherwise been applied to agricultural land outside of the project area.

Equation (28 estimates the leakage from imported manure, compost, or biosolids that are diverted from other applications and could have led to an increase in SOC outside the project boundary in the absence of the project activity. The total amount of carbon applied is reduced to 12% based on the global manure C retention coefficient from Maillard and Angers (2014). This value reflects the fraction of manure carbon expected to remain in project area soils. While derived for manure, the equation is also conservatively applied to compost and biosolids in this methodology.

$$LE_{OA,t} = \sum_{l} \left(M\_OA_{mp,l,t} \times CC_{mp,l,t} \times 0.12 \times \frac{44}{12} \right) \quad (28)$$

Where:

$LE_{OA,t}$	=	Leakage from organic amendments in year *t* (t CO_2e)
$M\_OA_{mp,l,t}$	=	Mass of organic amendment (from livestock type *l*) applied as fertilizer in the project area in year *t* (tonnes)
$CC_{mp,l,t}$	=	Carbon content of organic amendment (from livestock type *l*) applied as fertilizer in the project area in year *t* (t C/t manure)
0.12	=	Fraction of manure (i.e., organic amendment) carbon expected to remain in project area soils (Maillard & Angers, 2014) (unitless)

44/12 = Ratio of molecular weight of carbon dioxide to carbon

Note – as set out in Section 4, project activities that result in a material decline in the volume of biomass to soils in the project are ineligible under this methodology.

8.4.2 Leakage from Rice Yield Declines

Market leakage (LE_{yield}) is likely to be negligible because the land remains in rice production in the monitoring period. Further, producers are unlikely to implement and maintain rice production practices that result in productivity declines, since their livelihoods depend on rice yield as a source of income. Nevertheless, to ensure leakage is not occurring, the following steps must be completed during the first monitoring period. Where material leakage is detected, the steps must be repeated each season of the project until no material yield decrease is detected. Where no material decrease in yield is detected, these steps need not be repeated until the first monitoring period of the subsequent crediting period.

Step 1: Demonstrate that rice yield has not declined by more than 5% in the monitoring period by:

1) Comparing average monitoring period rice yield (excluding years with extreme weather events) during the project period to average baseline rice yield during the historical look-back period, using Equation (29). Where yield has improved, stayed constant, or declined by less than 5%, no further action is needed and LE_{yield}, should be set to 0. Where a reduction in yield of greater than 5% is observed, complete Step 2.

$$\Delta P = \left(\frac{P_{mp} - P_{bsl}}{P_{bsl}}\right) \times 100 \tag{29}$$

Where:

ΔP	=	Change in productivity (%)
P_{mp}	=	Average rice yield during the monitoring period (output/ha)
P_{bsl}	=	Average rice yield during the historical look-back period (output/ha)

Or

2) Comparing the ratio of average baseline rice yield to average regional rice yield during the historical look-back period with the ratio of average monitoring period rice yield to average regional rice yield during the monitoring period, using Equation (30) and regional data from government, industry, peer-reviewed, academic, or international organization (e.g., FAO or IRRI) sources.

$$\Delta PR = \left(\frac{P_{mp}}{RP_{mp}} - \frac{P_{bsl}}{RP_{bsl}}\right) \times 100 \quad (30)$$

Where:

ΔPR	=	Change in rice yield ratio per hectare (%)
RP_{mp}	=	Average regional rice yield during the monitoring period (output/ha)
RP_{bsl}	=	Average regional rice yield during the historical look-back period (output/ha)

For new rice paddy production techniques introduced as part of the project (e.g., DSR, nitrification inhibitors, reduced rice straw burning) that are not present in the historical look-back period, projects should use regional data sources instead of project-specific data sources, to determine historical rice yield and set P_{bsl} equal to RP_{bsl}.

Monitoring period yield averages must be based on data collected in the previous 10 years. Yield averages must not include data that are more than 10 years old. Where yield has improved, stayed constant, or declined by less than 5%, no further action is needed. Where a reduction in yield of greater than 5% is observed, complete Step 2.

Step 2: Determine whether the yield decline was caused by a short-term yield decrease by repeating the calculation in Step 1 excluding all data inputs from the first three years of project implementation. Where the monitoring period yield with the first three years removed is within 5% of the baseline yield, no further action is needed, and LE_{yield}, should be set to 0. Where a reduction in yield of greater than 5% is still observed, complete Step 3.

Step 3: Determine whether the yield decline is limited to a certain combination of factors by stratifying the analysis by:

1) Practice change category,
2) Practice change category combinations,
3) Soil type, and/or
4) Climatic zone.

Where the yield decline is limited to a certain combination of project implementation activities, that combination of project activities becomes ineligible for future crediting, until the yield decline is demonstrated to have been remedied. For example, where a 10% decline in rice yields is observed and stratification shows that the yield decline is linked to fertilizer rate reductions combined with DSR, rate reduction practices on DSR fields would no longer be eligible for future crediting until the project monitoring plan is updated to include measures to address the issue, and until the project proponent demonstrates no leakage has occurred pursuant to this section. Where a yield decline above 5% is not limited to a certain combination of project implementation activities, the portion of the observed yield decline above 5% is used to set the value for LE_{yield}.

8.4.3 Leakage from Diversion of Biomass Residues Used for Energy Applications in the Baseline Scenario

Where manure or crop residue management is a component of the project activity, and the manure or crop residues are diverted from energy applications (e.g., fuel for cookstoves or biomass power generation) in the baseline scenario, there is a risk of leakage. Due to implementation of the project activity, these competing applications may be forced to use inputs which are not carbon neutral. Leakage emissions due to the diversion of biomass used in the baseline for renewable fuel production ($LE_{BR,t}$) must be determined following procedures in CDM *TOOL16 Project and leakage emissions from biomass*.[26]

8.5 Uncertainty

8.5.1 Quantification Approach 1

Quantification Approach 1 is a modeling approach in which a biogeochemical model is used to simulate changes in GHG fluxes over a given time period in both the monitoring period and baseline scenarios.

Project proponents must use the guidance in *VM0042* (Table 8, Section 8.3) and *VMD0053* with respect to modeling under Quantification Approach 1.

Key sources of error accounted for under Quantification Approach 1 include:

- **Model prediction error** resulting from uncertainty in model parameters or model structural errors (i.e., inaccurate representation of actual biogeochemical processes). Model prediction error is calculated using independent statistical validation datasets per the processes outlined in *VMD0053*. Alternatively, project proponents may account for model prediction error by calibrating models to include parameter uncertainty (e.g., a Bayesian implementation of the model) and using the Monte Carlo simulation or error propagation approach detailed below.
- **Sampling error** resulting from measuring/modeling only a portion of the project area. Estimates of sampling error are contingent on the sampling design employed by the project proponent.
- **Measurement error** of model inputs. In many cases, the impact of these measurement errors on the error of reduction and removal estimates is assumed to be captured in model prediction error and/or sampling error.

[26] Available at: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-16-v2.pdf/history_view

For each GHG flux, these sources of error are estimated separately and then combined to estimate a single uncertainty deduction for that GHG flux across the entire project.

8.5.2 Quantification Approach 2

Quantification Approach 2 is applicable for flux of CH_4 and optionally also N_2O. The baseline is represented by control sites that are linked to one or more project quantification units. The GHG flux difference and its uncertainty is calculated based on comparisons of control sites and paired project quantification units. Key sources of error accounted for under Quantification Approach 2 include:

- **Sampling error** derived from only measuring or modeling a subset of the entire project area, resulting in a potentially inaccurate estimate of the true variance of a GHG flux. Sampling error is determined by calculating the approximate standard error of GHG fluxes as directly measured following the guidance in Section 9.1.
- **Measurement error** of methods used to determine GHG trace measurements at sample points. Where samples are collected in accordance with the guidance in Section 9.1, these errors are assumed to be unbiased and negligible.

These sources of error are estimated separately and then combined to estimate a single uncertainty deduction for GHG flux across the entire project. An analytical error propagation should be used. In this approach, the various sources of error outlined above are independently estimated for each GHG source or carbon pool that results in a reduction (e.g., CH_4, N_2O) or removal. The estimated errors are then combined to provide an estimate of the total variance of the areal mean reductions and removals across the project for each source in each verification period ($s^2_{\Delta\bullet,t}$). This is used to determine an appropriate uncertainty deduction.

This section is based on a stratified random sampling design in which the entire project is divided into strata and points are randomly allocated (with replacement) within the strata. GHG flux measurements are collected at these points. Formulae for uncertainty estimators are drawn from Som (1995, Ch. 10). Project-specific strata, their area, and the sampling points within strata must be reported in a spreadsheet and submitted as an annex to project documentation at every verification. This information feeds into Equation (31) for the parameters stratum identifier (h), area of stratum (A_h), and sample point identifier (ip).

$$S^2_{sampling,\Delta\bullet,t} = \sum_{h=1}^{H} S^2_{sampling,\Delta\bullet,h,t} \tag{31}$$

Where:

$$S^2_{sampling,\Delta\bullet,h,t} = \frac{A_h^2}{n_h(n_h - 1)} \sum_{ip=1}^{n_h} \left(\Delta \bullet_{h,ip,t} - \overline{\Delta \bullet_{h,t}}\right)^2 \quad (32)$$

And:

$S^2_{sampling,\Delta\bullet,t}$	=	Variance of reductions or removals in gas • due to sampling error at time *t* across the entire project area (t CO_2e)[2]
$S^2_{sampling,\Delta\bullet,h,t}$	=	Variance of reductions or removals in gas • within stratum *h* due to sampling error at time *t* (t CO_2e)[2]
$\overline{\Delta \bullet_{h,t}}$	=	Areal mean reduction or removal in gas • in stratum *h* at time *t*, computed as the average across the sample points in stratum *h* (t CO_2e/ha)
$\Delta \bullet_{h,ip,t}$	=	Estimated reduction or removal of gas • on an area basis in year *t* in stratum *h* at point *ip* (t CO_2e/ha)
h	=	1, …, *H* strata across the entire project area
ip	=	1, …, n_h sample points within stratum *h*
A_h	=	Area of stratum *h*

The variance of $\overline{\Delta \bullet_t}$ incorporating sample uncertainty is estimated by dividing the variance estimates of error sources by the square of the total project area (Cochran, 1977 Eq. 13.39; Som, 1995 Eq. 25.10).

$$S^2_{\Delta\bullet,t} = \frac{S^2_{sampling,\Delta\bullet,t}}{A^2} \quad (33)$$

Where:

$S^2_{\Delta\bullet,t}$	=	Variance of the estimate of mean reductions or removals from gas • at time *t* (t CO_2e/ha)[2]
A	=	Total project area

8.5.3 Quantification Approach 3

Project proponents using global, regional, or national IPCC Tier 1 and Tier 1a emission factors, or sub-national emission factors for small-scale projects with reductions and removals at or below 60 000 t CO_2e per year must apply a standardized default uncertainty deduction of 15%.

Project proponents using sub-national emission factors for projects with reductions and removals above 60 000 t CO_2e per year must calculate the uncertainty associated with the given emission factors. Project proponents may derive sub-national emission factors using literature, following the guidance to derive Tier 2 emission factors in the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Uncertainty estimates must be derived from the source literature, or otherwise calculated in accordance with the guidance in Section 8.5.

8.5.4 Uncertainty Deductions

Uncertainty deductions are estimated and applied separately for each source of reductions and removals within the project boundary. This deduction is estimated using a probability of exceedance method as follows (see Section 2.4 of the *VCS Methodology Requirements, v4.4*):

$$UNC_{\overline{\Delta\bullet},t} = Uncertainty \times t_{\alpha=0.666} \qquad (34)$$

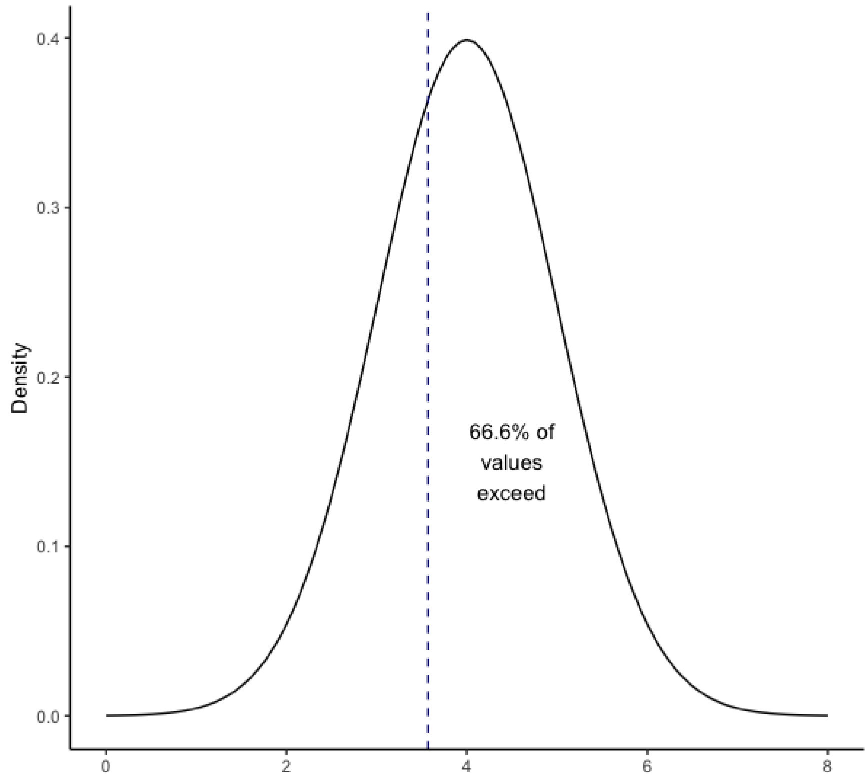
$$Uncertainty = \frac{\sqrt{s^2_{\overline{\Delta\bullet},t}}}{\overline{\Delta\bullet}_t} \times 100$$

Where:

$UNC_{\overline{\Delta\bullet},t}$	=	Uncertainty deduction for gas • to be applied in verification period t (%)
Uncertainty	=	Half-width of the one standard deviation interval as a percentage of the mean of the reduction or removal estimate for gas • in verification period t (%)
$\overline{\Delta\bullet}_t$	=	Mean estimated reduction or removal for gas • across the entire project area in year t (t CO_2e/ha)
$t_{\alpha=0.666}$	=	Critical value of a one-sided student's t-distribution at significance level α = 0.666 (66.6%) with degrees of freedom appropriate to the sampling design used. Equal to approximately 0.4307 at large sample sizes (dimensionless)

This uncertainty deduction is based on a defined threshold in the estimated probability density function of the reduction or removal for a given source. This enables a judgement of the extent to which the achieved removal or reduction by the project may be expected to be accurate. By this procedure, one estimates what percentage of the estimates of $\overline{\Delta\bullet}_t$ would have a 66.6% probability of exceeding the true value of $\overline{\Delta\bullet}_t$. That percentage is then used as the uncertainty deduction. Figure 2 demonstrates this concept.

Figure 2: Probability of exceedance. The value for $\overline{\Delta \bullet}_t$ used in calculation of VCUs issued is determined by applying an uncertainty deduction based on the 33.3rd percentile of the estimated probability distribution of $\overline{\Delta \cdot}_t$



8.6 Estimated GHG Emission Reductions

The method for calculating net reductions and removals differs depending on which quantification approaches are chosen for the project.

Regardless of which quantification approach is applied, Equation (35) is used to calculate net reductions. The subsequent sections provide guidance for how certain parameter values in Equation (35) are derived differently based on the choice of quantification approach.

For projects using Quantification Approach 2, $UNC_{t,CH4\_soil}$ and $UNC_{t,N2O\_soil}$ must be calculated in accordance with the guidance in Section 8.5.2.

For projects using Quantification Approach 3, $UNC_{t,CH4\_soil}$ and $UNC_{t,N2O\_soil}$ must be calculated in accordance with the guidance in Section 8.5.3.

$$ER_t = \Delta CO2\_ff_t + \Delta CO2\_lime_t + \Delta CH4\_bb_t + \left(\Delta CH4\_soil_t \times \left(1 - UNC_{t,CH4\_soil}\right)\right) + \left(\Delta N2O\_soil_t \times \left(1 - UNC_{t,N2O\_soil}\right)\right) + \Delta N2O\_bb_t - LE_{OA,t} - LE_{BR,t} - LE_{yield,t} - PE_{AB,t} - PE_{Red-Irri,t} - N2O\_fert_{LCA} \quad (35)$$

Where:

ER_t	=	Estimated net reductions in year t (t CO_2e)
$\Delta CO_2\_ff_t$	=	Total carbon dioxide reductions from fossil fuel combustion in year t (t CO_2e)
$\Delta CO2\_lime_t$	=	Total carbon dioxide reductions from liming in year t (t CO_2e)
$\Delta CH4\_bb_t$	=	Total methane reductions from avoided or reduced biomass burning in year t (t CO_2e)
$\Delta CH4\_soil_t$	=	Total methane reductions from soils in year t (t CO_2e)
$UNC_{t,CH4\_soil}$	=	Uncertainty deduction in year t when using Quantification Approach 1 to model methane reductions from soil (fraction between 0 and 1)
$\Delta N2O\_soil_t$	=	Total nitrous oxide reductions from nitrification/denitrification in year t (t CO_2e)
$UNC_{t,N2O\_soil}$	=	Uncertainty deduction in year t when using Quantification Approach 1 to model nitrous oxide reductions from nitrification/denitrification (fraction between 0 and 1)
$\Delta N2O\_bb_t$	=	Total nitrous oxide reductions from avoided or reduced biomass burning in year t (t CO_2e)
$LE_{BR,t}$	=	Leakage from diversion of biomass residues used for energy application in the baseline scenario
$LE_{yield,t}$	=	Leakage from rice yield declines

8.6.1 Methane Reductions ($\Delta CH4_t$)

Quantification Approach 1: Modeling

Methane reductions from soil methanogenesis are quantified as:

$$\Delta CH4\_soil_t = \sum_{i=1}^{n}\left(\overline{CH4\_soil_{bsl,i,t}} - \overline{CH4\_soil_{mp,i,t}}\right) \times A_i \quad (36)$$

Where:

$\overline{CH4\_soil_{mp,i,t}}$	=	Areal mean methane emissions from soil methanogenesis in the monitoring period for quantification unit i in year t (t CO_2e/ha)

Methane reductions from avoided or reduced biomass burning are quantified as:

$$\Delta CH4\_bb_t = \sum_{i=1}^{n}(\overline{CH4\_bb_{bsl,i,t}} - \overline{CH4\_bb_{mp,i,t}}) \times A_i \quad (37)$$

Where:

$\overline{CH4\_bb_{mp,i,t}}$	=	Areal mean methane emissions from biomass burning in the monitoring period for quantification unit *i* in year *t* (t CO_2e/ha)

Quantification Approach 2: Direct Measurement

For projects using Quantification Approach 2, the values in Equation (36) for $\Delta CH4\_soil_t$ must be set using Section 8.2.1.

Quantification Approach 3: Default Factors (Global/Regional/National/Subnational)

For projects using Quantification Approach 3, the values in Equation (35 for $\Delta CH4\_soil_t$ must be derived from the equations below. Note that the values for $BECH_{4,t}$ and $PECH_{4,t}$ must be derived using Equation (18)-(20).

$$\Delta CH4\_soil_t = BE_{CH4,t} - PE_{CH4,t} \quad (38)$$

8.6.2 Nitrous Oxide Reductions ($\Delta N2O_t$)

Nitrous oxide reductions from nitrification/denitrification are quantified as:

$$\Delta N2O\_soil_t = \sum_{i=1}^{n}(\overline{N2O\_soil_{bsl,i,t}} - \overline{N2O\_soil_{mp,i,t}}) \times A_i \quad (39)$$

Where:

$\overline{N2O\_soil_{mp,i,t}}$	=	Areal mean nitrous oxide emissions from nitrogen inputs to soils in the monitoring period for quantification unit *i* in year *t* (t CO_2e/ha)

Nitrous oxide reductions from biomass burning are quantified as:

$$\Delta N2O\_bb_t = \sum_{i=1}^{n}(\overline{N2O\_bb_{bsl,i,t}} - \overline{N2O\_bb_{mp,i,t}}) \times A_i \quad (40)$$

Where:

$\overline{N2O\_bb_{mp,i,t}}$	=	Nitrous oxide emissions from biomass burning in the monitoring period for quantification unit *i* in year *t* (t CO_2e/ha)

Quantification Approach 1: Modeling

For projects using Quantification Approach 1, the values for $\Delta N20\_soil_t$ in Equation (39) come from modeling results.

Quantification Approach 3: Default Factors (Global/Regional/National/Subnational)

For projects using Quantification Approach 3, the value for $\Delta N20\_soil_t$ in Equation (39) must be set using Section 8.2.4.

9 MONITORING

Where discretion exists in the selection of a value for a parameter, the principle of conservativeness must be applied (see the most recent version of the VCS Standard).

Project activities are implemented during the rice cultivation season, and all monitoring parameters must be monitored during the whole year, including pre- and post rice cultivation season.

The project proponent must provide training and technical support during the cropping season to deliver appropriate information and guidance in field preparation, irrigation, drainage, and use of fertilizer to the farmer. Such support must be documented in a verifiable manner at both validation and verification stages (e.g., training protocol and documentation of on-site visits).

The training provided to project implementation staff and farmers must include training specific to the eligible project activities being employed. For example, where a new cultivar is introduced as part of the project, guidance must be given regarding any unique requirements for optimum cultivation of the new cultivar. Where implementing AWD as a project activity, project proponents must demonstrate that irrigation water falls to approximately 15 cm below the surface of the field during each drying event, for example by using a field water tube (pani pipe).[27]

All projects must meet the requirements in Section 3.19 of the *VCS Standard, v4.7* (or equivalent section in the most recent version) with respect to environmental impacts. Examples of potential negative environmental impacts of projects include potential harms to migratory birds associated with reductions in winter flooding and challenges associated with the introduction of genetically modified organisms.

Box 1 below provides guidance with respect to best practices for sourcing data for projects. Where possible, project proponents should employ digital monitoring, reporting, and verification (dMRV) tools – in particular remote sensing – to enable efficient third-party validation and

[27] International Rice Research Institute (IRRI) (n.d.). *Fact sheet - saving water with alternate wetting drying (AWD)*. Rice Knowledge Bank. Available online at: http://file-barisal.portal.gov.bd/uploads/84c360f5-ee48-46d2-b80b-71e9570f6dbe//61e/6fc/cfa/61e6fccfa64f0157141810.pdf

verification of project data. Appendix 2 provides guidance with respect to best practices for utilizing dMRV for projects developed under this methodology.

Box 1: Sources of qualitative and quantitative data

Sources of information for all undefined activity/management-related model input variables, and parameters – relevant to the baseline – must follow the requirements detailed below.

All qualitative information on ALM practices must be determined via consultation with, and substantiated with a signed attestation from, the farmer or landowner of the sample field during that period. Where the farmer or landowner is not able to provide qualitative information (e.g., a sample field is newly leased), the project proponent must follow the quantitative information hierarchy outlined below.

The following list specifies the allowable sources of quantitative information on ALM practices in descending order of preference, as available:

1) Historical management records supported by one or more forms of documented evidence pertaining to the selected sample field and period $t = -1$ to $t = -3$ (e.g., management logs, receipts or invoices, farm equipment specifications, logs or files containing machine and/or sensor data) or remote sensing (e.g., satellite imagery, manned aerial vehicle footage, drone imagery), where requisite information on ALM practices can be reliably determined with these methods (e.g., irrigation patterns before and during the cultivation period, the type and amount of synthetic N fertilizers and organic amendments, and the duration of the cultivation season).
2) Historical management plans supported by one or more forms of documented evidence pertaining to the selected sample field and period $t = -1$ to $t = -3$ (e.g., management plan, recommendations in writing solicited by the farmer or landowner from an agronomist). Where more than one value is documented in historical management plans (e.g., where a range of application rates are prescribed in written recommendations), the principle of conservativeness must be applied and the value that results in the lowest expected emissions in the baseline scenario must be selected.
3) A signed attestation from the farmer or landowner of the sample field during that period – where the attested value does not deviate significantly from other evidence-supported values for similar fields (e.g., fertilizer data from adjacent fields with the same crop, adjacent years of the same field, government data on application rates in that area, or statement from a local extension agent regarding local application rates). Digital technologies may be used to generate farmer attestations. For example, where an application is used to present information to a farmer and digitally record their acceptance of the information as accurately reflecting their cultivation practices, such a digital record is considered a farmer attestation. The validation/verification body (VVB) must determine whether the data are sufficient. In circumstances where this requirement is not met, Option 4 must be followed.

4) Regional (sub-national) average values derived from agricultural census data or other sources from within the 20-year period preceding the project start date or the 10 most recent iterations of the dataset, whichever is more recent. Where estimates have been disaggregated by ownership classes, those should be used. The estimates must be substantiated with a signed attestation from the farmer or landowner of the sample field during that period. Examples include the USDA National Agricultural Statistics Service Quick Stats database and USDA Agricultural Resource Management Survey. This hierarchy applies to any additional quantitative inputs required by the model (Quantification Approaches 1 and 2) or default factor (Quantification Approach 3) selected. The principle of conservativeness must be applied in all cases.

9.1 Monitoring Requirements for Quantification Approach 2

Project proponents implementing Quantification Approach 2 must engage suitably qualified and experienced staff, which may include third parties (i.e., independent consultants or members of research institutions, or staff of the project itself), to implement a direct measurement campaign. This section includes mandatory requirements and additional recommendations on direct measurement.

Project proponents must develop a detailed direct measurement plan for measuring CH_4. The detailed project plan must include details regarding the stratification methodology, sampling methodology, and gas analysis methodology. The stratification methodology must follow the guidance in Section 6 and Table 3. Each project must have a minimum of three sample locations per stratum for project fields and at least one baseline control site per stratum, and a minimum of three measurements per deployment (i.e., at least three chambers must be used per sample location or chambers may be moved around), per sample location.[28] Chambers may be moved between sample locations. A project with a single stratum would thus need at least 12 samples for each sampling event: 9 for project fields and 3 for baseline fields, per deployment.

All sampling must take place between 09:00 and 11:00 in the morning. Sampling must commence within one week after initial flooding at the commencement of each cultivation season. Gas samples must be taken at least weekly and measurements should continue until any significant fallow period commences (i.e., after harvest). Records must be kept demonstrating the timing of each sample, and the relevant management practices being deployed in each sample location.

Gas analysis must be undertaken using commercial gas chromatograph equipment, equipped with a flame ionization detector, by persons with suitable training and experience in

[28] Minamikawa, K. et al. (2015). *Guidelines for measuring CH_4 and N_2O emissions from rice paddies by a manually operated closed chamber method*. National Institute for Agro-Environmental Sciences, Japan, p. 8.

undertaking such analysis.[29] Where samples are analyzed in a laboratory, the project proponent must demonstrate that the given laboratory has experience with such analysis. Where samples are analyzed in a laboratory, vials must be transferred to the laboratory for analysis as soon as possible after each sampling event. Processes for handling vials, from initial sampling through until analysis of the gas is complete, must be documented. All gas analysis equipment must be operated by suitably trained staff, maintained and calibrated per the manufacturer specifications, and calibrated prior to every analysis using certified standard gases.[30]

Table 6: Summary of field direct measurement requirements

Element	Requirement
Sample locations per stratum	Baseline emissions: at least three Project emissions: at least three
Samples per deployment	At least three (i.e., at least three chambers must be used or chambers are moved around for three separate samples)
Exposure time	Sample within 30 minutes of closing chamber
Sample time of day	Between 09:00 and 11:00
CH_4 sample frequency	Weekly, during cultivation season
Duration of CH_4 sample regime	Commencing at first flooding, continuing until first significant fallow for each cultivation season

Once direct measurements for CH_4 are undertaken for one full season, they may be used for that same season for the duration of a 7-year crediting period, or for the first 5 years of a single 10-year crediting period. Undertaking direct measurements over multiple seasons is likely to decrease uncertainty. Whilst direct measurement data may be aggregated across an entire year to create an annual average emission factor, a seasonal emission factor from one season must not be used as the seasonal emission factor for any other season (i.e., in a double cropping system, direct measurements must be taken for both seasons).

9.2 Data and Parameters Available at Validation

Data/Parameter	$FFC_{bsl,j,i,t}$
Data unit	Liters
Description	Consumption of fossil fuel type *j* (gasoline or diesel) for quantification unit *i* in year *t* in the baseline scenario
Equations	(3

[29] *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Chapter 5, Box 5.2A (New).
[30] Ibid.

Source of data	See Box 1
Value applied	See Box 1
Justification of choice of data or description of measurement methods and procedures applied	Fossil fuel consumption may be monitored or the amount of fossil fuel combusted may be estimated using fuel efficiency (e.g., l/100 km, l/km, l/hour) of the vehicle and the appropriate unit of use for the selected fuel efficiency (e.g., km driven where efficiency is given in l/100 km).
Purpose of data	Calculation of baseline emissions
Comments	Fuel efficiency may be obtained from peer-reviewed studies or the latest version of the IPCC Guidelines (Volume 2, Chapter 3). For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	$M_{limestone,bsl,i,t}$ and $M_{dolomite,bsl,i,t}$
Data unit	tonnes/year
Description	Amount of calcitic limestone ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$)
Equations	(5
Source of data	See Box 1
Value applied	Amount of calcitic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$) applied to quantification unit *i* in year *t*
Justification of choice of data or description of measurement methods and procedures applied	All limestone and dolomite applied to soils should be included, even the proportion applied in mixture with fertilizers. Use of oxides (e.g., CaO) and hydroxides of lime for soil liming need not be included in the calculations to estimate CO_2 emissions from liming. Because these materials do not contain inorganic carbon, CO_2 is not released following soil application; it is only produced during material manufacture.
Purpose of data	Calculation of baseline emissions
Comments	For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	GWP_{CH4}
Data unit	t CO_2e/t CH_4
Description	Global warming potential for CH_4
Equations	(6
Source of data	Latest version of the *VCS Standard*
Value applied	28
Justification of choice of data or description of	The *VCS Standard* provides the GWPs that must be used under the VCS Program.

measurement methods and procedures applied	
Purpose of data	Calculation of baseline and project emissions
Comments	None

Data/Parameter	$MB_{bsl,c,i,t}$
Data unit	kg
Description	Mass of agricultural residues of type *c* burned in the baseline scenario for quantification unit *i* in year *t*
Equations	(6
Source of data	See Box 1
Value applied	See Box 1
Justification of choice of data or description of measurement methods and procedures applied	Peer-reviewed published data may be used to estimate aboveground biomass prior to burning.
Purpose of data	Calculation of baseline and project emissions
Comments	Mass of residues burned is a function of the amount of aboveground biomass, the removal of aboveground biomass, and whether remaining residues are burned. It is assumed that 100% of aboveground biomass is burned in the baseline scenario. For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	GWP_{N2O}
Data unit	t CO_2e/t N_2O
Description	Global warming potential for N_2O
Equations	(6, (7
Source of data	Latest version of the *VCS Standard*
Value applied	265
Justification of choice of data or description of measurement methods and procedures applied	The *VCS Standard* provides the GWPs that must be used under the VCS Program.
Purpose of data	Calculation of baseline and project emissions
Comments	None

Data/Parameter	$MB_{bsl,i,t}$
Data unit	t d.m.
Description	Annual mass of dry matter (above- and belowground) of rice straw returned to soils for quantification unit *i* in year *t*
Equations	(16
Source of data	See Box 1
Value applied	See Box 1
Justification of choice of data or description of measurement methods and procedures applied	See Box 1
Purpose of data	Calculation of baseline emissions
Comments	None

Data/Parameter	$EF_{bsl,c}$
Data unit	kg CH_4/ha/season
Description	Baseline emission factor for continuously flooded fields without organic amendment
Equations	(18
Source of data	Latest version of IPCC guidelines (Table 5.11, Chapter 5, Volume 4)
Value applied	Value depends on the country in which the project area is located. See Table 5.11 in data source.
Justification of choice of data or description of measurement methods and procedures applied	See "Source of data"
Purpose of data	Calculation of baseline and project emissions
Comments	Default values are to be considered at a national, regional, and global level, listed here in descending order of preference.

Data/Parameter	$SF_{bsl,w}$
Data unit	unitless
Description	Baseline scaling factor to account for differences in water regime during the cultivation period
Equations	(18
Source of data	Latest version of IPCC guidelines (Table 5.12, Chapter 5, Volume 4)

Value applied	Value depends on water regime employed: • Continuously flooded: 1 • Single drainage period: 0.71 • Multiple drainage periods: 0.55
Justification of choice of data or description of measurement methods and procedures applied	See "Source of data"
Purpose of data	Calculation of baseline and project emissions
Comments	For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	$SF_{bsl,p}$
Data unit	unitless
Description	Baseline scaling factor to account for differences in water regime in the pre-season before the cultivation period
Equations	(18
Source of data	Latest version of IPCC guidelines (Table 5.13, Chapter 5, Volume 4)
Value applied	Value depends on water regime employed: • Non-flooded pre-season <180 days (indicating double cropping): 1 • Non flooded pre-season >180 days (indicating single cropping): 0.89
Justification of choice of data or description of measurement methods and procedures applied	See "Source of data"
Purpose of data	Calculation of baseline and project emissions
Comments	For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	$SF_{bsl,o}$
Data unit	unitless
Description	Baseline scaling factors should vary for both type and amount of organic amendment applied
Equations	(18
Source of data	Latest version of IPCC guidelines (Table 5.14, Chapter 5, Volume 4)
Value applied	Value depends on type and amount of organic amendment applied:

	• Non-flooded pre-season <180 days (indicating double cropping): $(1 + 5 \times 1)^{0.59} = 2.88$ • Non flooded pre-season >180 days (indicating single cropping): $(1 + 5 \times 0.19)^{0.59} = 1.48$
Justification of choice of data or description of measurement methods and procedures applied	See "Source of data"
Purpose of data	Calculation of baseline and project emissions
Comments	For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	$CFOA_a$
Data unit	unitless
Description	Conversion factor for organic amendment type *a*
Equations	(19)
Source of data	Latest version of IPCC guidelines (Table 5.14, Chapter 5, Volume 4)
Value applied	Value depends on organic amendment type applied (see Section 8.5)
Justification of choice of data or description of measurement methods and procedures applied	See "Source of data." Where the project involves the introduction of a new cultivar that is known to have a materially larger root system to the cultivar(s) being deployed in the baseline, the change in root biomass must be accounted for using this scaling factor.
Purpose of data	Calculation of baseline and project emissions
Comments	None

Data/Parameter	CF_{N2O}
Data unit	kg N_2O/kg N-input
Description	N_2O correction factor based on IPCC (2019) or the latest version
Equations	(26
Source of data	The correction factor must be derived from the emission factors (kg N_2O-N/t N) from the latest version of IPCC guidelines Table 11.1 (Updated) in Chapter 11, Volume 4 .The difference between the aggregated default value emission factors for continuously flooded rice fields and rice fields with single or multiple drainage was converted from N_2O-N into N_2O emissions. See Appendix 3 for further details on how the correction factor was derived.
Value applied	0.00314

Justification of choice of data or description of measurement methods and procedures applied	See "Source of data"
Purpose of data	Calculation of baseline and project emissions
Comments	None

Data/Parameter	P_{bsl}
Data unit	Output/ha
Description	Average rice yield during the historical look-back period
Equations	(29, (30
Source of data	See Box 1
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Average productivity for each livestock/crop following guidance in Section 8.4.28.4.3
Purpose of data	Determination of baseline productivity for future market leakage analysis
Comments	For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	RP_{bsl}
Data unit	Output/ha
Description	Average regional rice yield during the historical look-back period
Equations	(30
Source of data	Secondary evidence sources of regional productivity (e.g., peer reviewed literature, industry associations, international databases, government databases)
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Average regional productivity for each livestock/crop product following guidance in Section 8.4.2
Purpose of data	Calculation of baseline emissions
Comments	For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

9.3 Data and Parameters Monitored

Data/Parameter	A_i
Data unit	ha
Description	Area of quantification unit *i*
Equations	(2, (4, (6, (9), (12), (15), (36), (37), (39), (40)
Source of data	Measurement of each quantification unit within the project area
Description of measurement methods and procedures to be applied	The quantification unit area is measured prior to verification.
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	Delineation of the quantification unit area may be determined using a combination of GIS coverages, ground survey data, remote imagery (satellite or aerial photographs), and other appropriate data. Any imagery or GIS datasets used must be geo-registered referencing corner points, landmarks, or other intersection points.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	Other units used to determine area (e.g., acres) must be converted to hectares.

Data/Parameter	$EF_{CO2,j}$
Data unit	t CO_2e/liter
Description	Emission factor for fossil fuel *j* (gasoline or diesel) combusted
Equations	(3)
Source of data	Latest version of IPCC guidelines (Table 3.3.1 in Chapter 3 Volume 2)
Description of measurement methods and procedures to be applied	For gasoline EF_{CO2} = 0.002810 t CO_2e per liter For diesel EF_{CO2} = 0.002886 t CO_2e per liter
Frequency of monitoring/recording	Source of data for emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	See “Source of data”
Purpose of data	Calculation of baseline and project emissions

Calculation method	N/A
Comments	Assumes four-stroke gasoline engine for gasoline combustion and default values for energy content of 47.1 GJ/t and 45.66 GJ/t for gasoline and diesel respectively (IEA, 2004).

Data/Parameter	$EF_{limestone}$ and $EF_{dolomite}$
Data unit	t C/(t limestone or dolomite)
Description	Emission factor for the application of calcitic limestone ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) (i.e., liming)
Equations	(5)
Source of data	Latest version of IPCC guidelines (Section 11.3, Chapter 11, Volume 4)
Description of measurement methods and procedures to be applied	IPCC (2019) values: • For calcitic limestone $EF_{limestone}$ = 0.12 t C/t limestone • For dolomite, $EF_{dolomite}$ = 0.13 t C/t dolomite.
Frequency of monitoring/recording	Source of data for emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	See “Source of Data” and Quantification Approach 3 in Section 8.3
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	CF_C
Data unit	Proportion of pre-fire fuel biomass consumed
Description	Consumption factor for agricultural residue type *c* (proportion of pre-fire fuel biomass consumed)
Equations	(6)
Source of data	Latest version of IPCC guidelines (Table 2.6 in Chapter 2, Volume 4)
Description of measurement methods and procedures to be applied	The combustion factor is selected based on the agricultural residue type burned.
Frequency of monitoring/recording	Source of data for combustion factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.

QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$EF_{c,CH4}$
Data unit	g CH_4/kg dry matter burned
Description	Methane emission factor for the burning of agricultural residue type *c*
Equations	(6)
Source of data	Latest version of IPCC guidelines (Table 2.5 in Chapter 2, Volume)
Description of measurement methods and procedures to be applied	The emission factor is selected based on the agricultural residue type burned.
Frequency of monitoring/recording	Source of data for the emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$EF_{c,N2O}$
Data unit	g N_2O/kg dry matter burned
Description	Nitrous oxide emission factor for the burning of agricultural residue type *c*
Equations	(6
Source of data	Where no information source is available that is applicable to the project conditions, project proponents may define value from the latest version of IPCC guidelines for Lookup Table 2.5 in Chapter 2, Volume 4 of IPCC (2019).
Description of measurement methods and procedures to be applied	The emission factor is selected based on the agricultural residue type.

Frequency of monitoring/recording	Source of data for the emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$f(N2O\_soil_{bsl,i,t})$
Data unit	t N_2O/ha
Description	Modeled nitrous oxide emissions from soil in the baseline scenario for quantification unit *i* in year *t,* calculated by modeling soil fluxes of nitrogen forms over the course of the preceding year
Equations	(7)
Source of data	Modeled in the project area
Description of measurement methods and procedures to be applied	Modeled nitrous oxide emissions from soil in the baseline scenario are determined according to the following equation: $f(N2O\_soil_{bsl,i,t}) = fN2O_{soil}(Val\ A_{bsl,i,t}, Val\ B_{bsl,i,t}, \ldots)$ Where: $f(N2O\_soil_{bsl,i,t})$ = Modeled nitrous oxide emissions from soil in the baseline scenario for quantification unit *i* in year *t*, calculated by modeling soil fluxes of nitrogen forms over the course of the preceding year (t N_2O/ha) $fN2O_{soil}$ = Model predicting nitrous oxide emissions from soils $Val\ A_{bsl,i,t}$ = Value of model input variable A in the baseline scenario for quantification unit *i* at time *t* (units unspecified) $Val\ B_{bsl,i,t}$ = Value of model input variable B in the baseline scenario for quantification unit *i* at time *t* (units unspecified) See Box 1 for sources of data and description of measurement methods and procedures to be applied to obtain values for model input variables.
Frequency of monitoring/recording	Monitoring must be conducted annually, or prior to each verification event where verification occurs more frequently.
QA/QC procedures to be applied	See *VMD0053*

Purpose of data	Calculation of baseline and project emissions in Quantification Approach 1
Calculation method	N/A
Comments	For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	$EF_{Ndirect}$
Data unit	t N_2O-N/t N applied
Description	Emission factor for direct nitrous oxide emissions from N additions from synthetic fertilizers, organic amendments, and crop residues
Equations	(9), (15)
Source of data	See Quantification Approach 3 in Section 8.3
Description of measurement methods and procedures to be applied	See "Source of data"
Frequency of monitoring/recording	Source of data for the emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available following the guidance under Quantification Approach 3 in Section 8.3.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	The emission factor is applicable to N additions from mineral fertilizers, organic amendments, and crop residues, and N mineralized from mineral soil. The emission factor must be chosen according to whether the climate in the given area is wet or dry. Wet climates occur in temperate and boreal zones where the ratio of annual precipitation to potential evapotranspiration is greater than 1, and in tropical zones where annual precipitation is greater than 1000 mm. Dry climates occur in temperate and boreal zones where the ratio of annual precipitation to potential evapotranspiration is less than 1, and in tropical zones where annual precipitation is less than 1000 mm.

Data/Parameter	NC_{SF}
Data unit	t N/t fertilizer
Description	N content of synthetic fertilizer type *SF*
Equations	(10)
Source of data	See Box 1

Description of measurement methods and procedures to be applied	N content is determined following fertilizer manufacturer's specifications.
Frequency of monitoring/recording	Monitoring must be conducted each season. Parameter value must be updated when synthetic fertilizer product is changed or when new manufacturer specifications are issued.
QA/QC procedures to be applied	See "Source of data" and Quantification Approach 3 in Section 8.3
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	*SF*
Data unit	Dimensionless
Description	Type of synthetic N fertilizer
Equations	(10)
Source of data	Determined in quantification unit *i*
Description of measurement methods and procedures to be applied	See Box 1. Synthetic fertilizer type is determined prior to verification.
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$M_{bsl,SF,i,t}$
Data unit	tonnes
Description	Mass of N-containing synthetic fertilizer type *SF* applied in the project for quantification unit *i* in year *t*
Equations	(10)

Source of data	Management records from project area
Description of measurement methods and procedures to be applied	See Box 1
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	NC_{OF}
Data unit	t N/t fertilizer
Description	N content of organic fertilizer type *OF*
Equations	(11)
Source of data	Peer-reviewed published data may be used. For example, default manure N content may be selected from Edmonds et al. (2003) cited in US EPA (2021) or other regionally appropriate sources such as the European Environment Agency.
Description of measurement methods and procedures to be applied	See “Source of data”
Frequency of monitoring/recording	Monitoring must be conducted each season. Parameter value must be updated when organic fertilizer product is changed or as new default values become available in peer-reviewed publications or databases.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	None

Data/Parameter	*OF*

Data unit	Dimensionless
Description	Type of organic N fertilizer
Equations	(11)
Source of data	Determined in quantification unit *i*
Description of measurement methods and procedures to be applied	See Box 1. Organic fertilizer type is determined prior to verification.
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$M_{bsl,OF,i,t}$
Data unit	tonnes
Description	Mass of N-containing organic fertilizer type *OF* applied in the project for quantification unit *i* in year *t*
Equations	(11)
Source of data	Management records from project area
Description of measurement methods and procedures to be applied	See Box 1
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	For all equations, the subscript *bsl* must be substituted by *mp* where the relevant values are being quantified for the monitoring period.

Data/Parameter	$Frac_{GASF,l,S}$
Data unit:	Dimensionless
Description	Fraction of all synthetic N added to soils that volatilizes as NH_3 and NO_x for livestock type *l*
Equations	(13)
Source of data	See Quantification Approach 3 in Section 8.3. Where no information source is available that is applicable to the project conditions, project proponents may define value from the latest version of IPCC guidelines for Lookup Table 10.22 in Chapter 10, Volume 4 of IPCC (2019).
Description of measurement methods and procedures to be applied	See "Source of data"
Frequency of monitoring/recording	Source of data for the emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$Frac_{GASM,l,S}$
Data unit:	Dimensionless
Description	Fraction of all organic N added to soils that volatilizes as NH_3 and NO_x for livestock type *l*
Equations	(13)
Source of data	See Quantification Approach 3 in Section 8.3. Where no information source is available that is applicable to the project conditions, project proponents may define value from the latest version of IPCC guidelines for Lookup Table 10.22 in Chapter 10, Volume 4 of IPCC (2019).
Description of measurement methods and procedures to be applied	See "Source of data"
Frequency of monitoring/recording	Source of data for the emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.

Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	EF_{Nvolat}
Data unit:	t N_2O-N/(t NH_3-N + NO_x-N volatilized)
Description	Emission factor for nitrous oxide emissions from atmospheric deposition of N on soils and water surfaces
Equations	(13)
Source of data	See Quantification Approach 3 in Section 8.3. Where no information source is available that is applicable to the project conditions, project proponents may define value from latest version of IPCC guidelines for Lookup Table 11.3 in Chapter 11, Volume 4 of IPCC (2019).
Description of measurement methods and procedures to be applied	See "Source of data"
Frequency of monitoring/recording	Source of data for the emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$Frac_{LEACH,l,S}$
Data unit	Dimensionless
Description	Fraction of N (synthetic or organic) added to soils that is lost through leaching and runoff, in regions where leaching and runoff occurs, for livestock type *l* and manure management system *S*
Equations	(14)
Source of data	See Quantification Approach 3 in Section 8.3. Where no information source is available that is applicable to the project conditions, project proponents may define value from latest version of IPCC guidelines for Lookup Table 11.3 in Chapter 11, Volume 4 of IPCC (2019).
Description of measurement methods	When using values from IPCC (2019), for wet climates and for dry climate regions where irrigation (other than drip irrigation) is used, a

and procedures to be applied	value of 0.24 is applied. For all other dry climate regions, a value of zero is applied.
Frequency of monitoring/recording	Source of data for the emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	Wet climates occur in temperate and boreal zones where the ratio of annual precipitation to potential evapotranspiration is greater than 1, and in tropical zones where annual precipitation is greater than 1000 mm. Dry climates occur in temperate and boreal zones where the ratio of annual precipitation to potential evapotranspiration is less than 1, and in tropical zones where annual precipitation is less than 1000 mm.

Data/Parameter	EF_{Nleach}
Data unit	t N_2O-N/t N leached and runoff
Description	Emission factor for nitrous oxide emissions from leaching and runoff
Equations	(14)
Source of data	See Quantification Approach 3 in Section 8.3. Where no information source is available that is applicable to the project conditions, project proponents may define value from the latest version of IPCC guidelines for Lookup Table 11.3 in Chapter 11, Volume 4 of IPCC (2019).
Description of measurement methods and procedures to be applied	See "Source of data"
Frequency of monitoring/recording	Source of data for the emission factor must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$N_{content}$
Data unit	t N/t dm

Description	Fraction of N in dry matter for rice straw
Equations	(16)
Source of data	See Quantification Approach 3 in Section 8.3. Where no information source is available that is applicable to the project conditions, project proponents may define value from the latest version of IPCC guidelines for Lookup Table 11.2 in Chapter 11, Volume 4 of IPCC (2019).
Description of measurement methods and procedures to be applied	The fraction of N in dry matter is determined based on the species type (in this case rice straw).
Frequency of monitoring/recording	Source of data for this value must be monitored every five years and must be updated when more accurate data applicable to the project conditions become available.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$f(CH4\_soil_{bsl,i,t})$
Data unit	t CH_4/ha
Description	Modeled methane emissions from soil in the baseline scenario for quantification unit *i* at time *t*, calculated by modeling soil methane fluxes over the course of the preceding year
Equations	(17)
Source of data	Modeled in the project area
Description of measurement methods and procedures to be applied	Modeled CH_4 emissions from the soil methanogenesis in the baseline scenario are determined according to the following equation: $f(CH4\_soil_{bsl,i,t}) = f_{CH4soil}(Val\ A_{bsl,i,t}, Val\ B_{bsl,i,t}, \ldots)$ Where: $f(CH4\_soil_{bsl,i,t})$ = Modeled methane emissions from soil methanogenesis in the baseline scenario for quantification unit *i* at time *t* (t CH_4/ha) $f_{CH4soil}$ = Model predicting methane emissions from soil methanogenesis $Val\ A_{bsl,i,t}$ = Value of model input variable A in the baseline scenario for quantification unit *i* at time *t* (units unspecified) $Val\ B_{bsl,i,t}$ = Value of model input variable B in the baseline scenario for quantification unit *i* at time *t* (units unspecified)

	See Box 1 for sources of data and description of measurement methods and procedures to be applied to obtain values for model input variables.
Frequency of monitoring/recording	Monitoring must be conducted annually, or prior to each verification event where verification occurs more frequently.
QA/QC procedures to be applied	See *VMD0053*
Purpose of data	Calculation of baseline and project emissions in Quantification Approach 1
Calculation method	Methods are specific to model used.
Comments	None

Data/Parameter	ROA_a
Data unit:	tonnes/hectare
Description	Application rate of organic amendment type *a,* in dry weight of straw and fresh weight for others
Equations	(19)
Source of data	Management records from project area
Description of measurement methods and procedures to be applied	See Box 1
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	See Box 1
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	L_t
Data unit	days/year
Description	Cultivation period of rice in year *t*
Equations	(20)

Source of data	Farm management records In circumstances where climatic conditions result in a monitoring period's cultivation season lasting longer than the baseline cultivation season, project proponents may set the baseline cultivation season duration as the number of days in the cultivation season during the monitoring period. In such circumstances the value for the monitoring period cultivation season duration must be set using baseline control sites, following the guidance in Section 6.
Description of measurement methods and procedures to be applied	See Box 1
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	See Box 1
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$Conc_{CH4,pt}$
Data unit	ppm
Description	Methane concentration in chamber at time *pt*, from gas analysis
Equations	(21)
Source of data	Measured in the project area
Description of measurement methods and procedures to be applied	See Section 9.1
Frequency of monitoring/recording	Monitoring must be conducted annually, or prior to each verification event where verification occurs more frequently.
QA/QC procedures to be applied	See Section 9.1
Purpose of data	Calculation of baseline and project emissions under Quantification Approach 2
Calculation method	N/A
Comments	None

Data/Parameter	Vol_{ch}
Data unit	Liters
Description	Chamber volume from direct measurement of methane emissions
Equations	(21)
Source of data	Measured in the project area
Description of measurement methods and procedures to be applied	See Section 9.1
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	See Section 9.1
Purpose of data	Calculation of baseline and project emissions under Quantification Approach 2
Calculation method	N/A
Comments	None

Data/Parameter	T_{pt}
Data unit	Kelvin
Description	Temperature at time *pt*
Equations	(21)
Source of data	Measured
Description of measurement methods and procedures to be applied	See Section 9.1
Frequency of monitoring/recording	Monitoring must be conducted annually, or prior to each verification event where verification occurs more frequently.
QA/QC procedures to be applied	See Section 9.1
Purpose of data	Calculation of baseline and project emissions under Quantification Approach 2

Calculation method	N/A
Comments	None

Data/Parameter	A_{ch}
Data unit	m^2
Description	Chamber area
Equations	(23)
Source of data	Measured
Description of measurement methods and procedures to be applied	See Section 9.1
Frequency of monitoring/recording	Must be monitored once per chamber.
QA/QC procedures to be applied	See Section 9.1
Purpose of data	Calculation of baseline and project emissions under Quantification Approach 2
Calculation method	N/A
Comments	None

Data/Parameter	*Nch*
Data unit	Dimensionless
Description	Number of replicate chambers per plot
Equations	(24)
Source of data	Measured
Description of measurement methods and procedures to be applied	See Section 9.1
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	See Section 9.1

Purpose of data	Calculation of baseline and project emissions under Quantification Approach 2
Calculation method	N/A
Comments	None

Data/Parameter	$EF_{eu,r}$
Data unit	t CO_2e/t dry rice straw
Description	Emission factor for off-farm end uses of dry rice straw, per end use category *r*
Equations	(25)
Source of data	Table 5
Description of measurement methods and procedures to be applied	See Table 5
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$RS_{removed,r}$
Data unit:	tonnes
Description	Volume of rice straw removed from field and sent to end use category *r*
Equations	(25)
Source of data	Table 5
Description of measurement methods and procedures to be applied	See Table 5
Frequency of monitoring/recording	Monitoring must be conducted each season.

QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$Q_{N,s}$
Data unit:	kg N/ha
Description	Application rate of N inputs in the monitoring
Equations	(26)
Source of data	Fertilizer application log books from farmers; surveys among farmers
Description of measurement methods and procedures to be applied	See Box 1
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	Consolidated purchase receipts may be used to check the N inputs.
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	None

Data/Parameter	A_s
Data unit	ha
Description	Area of project fields where the application rate of N input in the project does not exceed that of the baseline in quantification unit *i* in year *t*
Equations	(26)
Source of data	Determined in the project area in conjunction with fertilizer logbooks and/or surveys among farmers
Description of measurement methods and procedures to be applied	See Box 1

Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	To be determined by collecting the project field sizes based on stratification in a project database. The size of project fields is determined by GPS or satellite data. Where such technologies are not available, established field size measurement approaches must be used provided that uncertainties are taken into account in a conservative manner. Scaled maps that show the project fields clearly will help in ascertaining exact area. Remote sensing images of appropriate resolution may be used to ascertain the project boundary and area under various strata and area groups with high confidence.
Purpose of data	Calculation of project emissions
Calculation method	N/A
Comments	None

Data/Parameter	$M\_OA_{mp,l,t}$
Data unit	tonnes
Description	Mass of organic amendment (from livestock type *l*) applied as fertilizer on the project area in year *t*
Equations	(28)
Source of data	Management records from project area
Description of measurement methods and procedures to be applied	For manure application, data should be disaggregated for each livestock type *l*.
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of leakage from application of new organic amendments from outside of the project area
Calculation method	N/A
Comments	None

Data/Parameter	$CC_{mp,l,t}$
Data unit	t C/t organic amendment

Description	Carbon content of organic amendment from livestock type *l* applied as fertilizer in the project area in year *t*
Equations	(28)
Source of data	See Box 1
Description of measurement methods and procedures to be applied	Record of carbon content of manure
Frequency of monitoring/recording	Monitoring must be conducted every five years, or prior to each verification event where verification occurs more frequently.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Calculation of project emissions from leakage
Calculation method	N/A
Comments	None

Data/Parameter	P_{mp}
Data unit	Output (e.g., kg)/ha
Description	Average rice yield during the monitoring period
Equations	(29), (30)
Source of data	Farm productivity (e.g., yield) records
Description of measurement methods and procedures to be applied	Measured using locally available technologies (e.g., mobile weighing devices, commercial scales, storage volume measurements, fixed scales, weigh scale tickets)
Frequency of monitoring/recording	Monitoring must be conducted each season.
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Determination of project productivity for market leakage analysis
Calculation method	N/A
Comments	None

Data/Parameter	RP_{mp}

Data unit	Output (e.g., kg)/ha
Description	Average regional rice yield during the monitoring period
Equations	(30)
Source of data	Regional productivity data from government (e.g., USDA Actual Production History data), industry, published, academic, or international organization (e.g., FAO) sources
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every 10 years
QA/QC procedures to be applied	Guidance provided in IPCC (2003) Section 5.5 or IPCC (2000) Chapter 8 must be applied.
Purpose of data	Determination of project productivity ratio for market leakage analysis
Calculation method	N/A
Comments	None

Data/Parameter	h
Data unit	Dimensionless
Description	Stratum h covers all project fields with the same cultivation pattern
Equations	(31), (32)
Source of data	Determined in project area
Description of measurement methods and procedures to be applied	Project fields are grouped by cultivation pattern.
Frequency of monitoring/recording	Monitoring must be conducted annually, or prior to each verification event where verification occurs more frequently.
QA/QC procedures to be applied	None
Purpose of data	Calculation of baseline and project emissions
Calculation method	N/A
Comments	None

9.4 Description of the Monitoring Plan

The main objective of monitoring is to quantify emissions of CO_2, CH_4, and N_2O resulting from the monitoring period during the verification period.

Project proponents must detail the procedures for collecting and reporting all data and parameters listed in Section 9.3. The monitoring plan must contain at least the following information:

- Description of each monitoring task to be undertaken, and the technical requirements therein;
- Definition of the accounting boundary, spatially delineating any differences in the accounting boundaries and/or quantification approaches;
- Parameters to be measured, including any parameters required for the selected model (additional to those specified in this methodology);
- Data to be collected and data collection techniques and sample designs for directly sampled parameters;
- Ten-year baseline re-evaluation plan, detailing source of regional (sub-national) agricultural production data and procedures to revise the baseline schedule of activities;
- Quality assurance and quality control (QA/QC) procedures to ensure accurate data collection; screen for, and where necessary, correct anomalous values; ensure completeness; perform independent checks on analysis results and other safeguards as appropriate;
- Data archiving procedures, including procedures for any anticipated updates to electronic file formats. All data collected as a part of monitoring, including QA/QC data, must be archived electronically and kept for at least two years after the end of the last project crediting period;
- Roles, responsibilities, and capacity of monitoring team and management; and
- Modeling plan, where Quantification Approach 1 is applied. The project modeling plan must describe the model(s) selected, describe the datasets used for model validation and calibration, including their sources, and specify the baseline schedule of rice cultivation activities for each quantification unit (fixed ex ante).

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APPENDIX 1: GUIDANCE FOR DIGITAL MONITORING, REPORTING, AND VERIFICATION (DMRV)

Under this methodology, project proponents are encouraged to employ digital monitoring, reporting, and verification (dMRV) tools, in particular remote sensing, to efficiently enable third-party validation of project data. This appendix provides guidance with respect to best practices for utilizing dMRV for projects developed under this methodology.

Table A2.1: Guidance for QA/QC best practices for use of dMRV

dMRV Type	Issue	Guidance	Example Use
Remote Sensing (RS)	Temporal/spatial resolution	Consider setting a minimum spatial and temporal resolution, differentiated based on the intended use.	A project proponent uses RS to detect irrigation events. The project proponent ensures satellite image frequency is high enough to capture the typical and/or expected dry period duration for project farmers. The project proponent employs the use of satellite imagery with 2–4-day frequency around expected irrigation events, as they know that the farmers typically dry their fields for 4–5 days.
	Bands/types of data	Consider setting requirements for bands and types of data, differentiated based on intended use.	A project uses radar to detect moisture levels in the soil. The project deploys different wavelengths depending on seasonal timing. This ensures that as the crop matures and the canopy closes over the ground, obstructing view of the soil, the wavelength chosen for latter parts of the season can penetrate the canopy and effectively determine soil moisture.
	Correction	Remote sensing data should be corrected to surface reflectance units (atmospheric correction) and filtered for clouds and cloud shadows. Consider limiting the amount of correction that may be applied to a single scene.	A project proponent uses three separate satellite datasets. For one drying event on a specific field, the satellite feeds from all three datasets are partially covered by clouds. The project proponent determines that correcting all three available data feeds would be excessive, and therefore determines not to use any such data to determine values for that parameter.

			The project proponent documents this and uses alternative data for this parameter value.
	Verifiability	Only use publicly available RS datasets or ensure all proprietary RS data is made available to the VVB to enable them to validate/verify work undertaken.	A project proponent uses a combination of public and proprietary RS datasets and provides the VVB access to their GIS-enabled platform, enabling the VVB to undertake spot checks.
		Project proponents should only use RS to create data that can be independently verified.	A project proponent uses RS to demonstrate fields were double cropped. The project employs a GIS-enabled platform and allows the VVB access, enabling the VVB to have an efficient means to validate historical and contemporary double cropping via remote desktop audits.
Machine learning/ artificial intelligence (ML/AI)	Features	Project proponents should report on their feature set and explain how each feature is relevant to the task at hand. Such data may be marked as confidential, in which case it will not be made publicly available but will be available to the VVB and Verra.	A project reports on their ML/AI model feature set, provides the VVB with a summary description of how the model uses such features, and gives the VVB opportunities to test the model and ask questions regarding how it works. This ensures the system is not a “black box,” enabling more effective validation and verification of its use.
	Validation	Project proponents should validate ML/AI model results against independent ground truth data, using either cross-validation (preferably spatial rather than random) and/or independent holdout datasets.	A project proponent provides the VVB and Verra with an analysis of how the model was validated, as an additional layer of assurance.
	Verifiability	Project proponents should only use ML/AI to create data that can be independently verified.	A project proponent uses an ML/AI model to create digital maps of project areas and estimate field size. VVBs can then independently use RS software (such as Google Earth) to estimate field size, as well as review other datapoints from the project, and then use these to validate the ML/AI model outputs.
		Project proponents should identify clear means to test their ML/AI tools, to facilitate VVB spot-checking.	A project proponent provides the VVB access to their GIS-enabled platform, enabling the VVB to undertake spot checks of any farm against other

			datasets provided by the project proponent, publicly available data, and other data gathered by the VVB.
All dMRV systems	Ground truthing	Project proponents should compare data from multiple sources (as outlined in Box 1), including: • Farmer logbooks; • Literature and/or government/public datasets; • Remote sensing data.	A project proponent uses digital farmer logbooks to capture data for the full schedule of activities. RS tools are then used to verify many of the most critical datapoints, such as confirming rice was grown, field preparation dates, irrigation dates, dry period dates and duration, harvest date, and burning of rice straw. The project proponent makes all data and the GIS-enabled tool available to the VVB to perform independent spot checks at the VVB's discretion.
	Ground truthing	Project proponents should: 1) Create typical value ranges for key parameters (e.g., using literature, government/public datasets) and flag any significant deviation from the range; 2) Create a clear process to be followed to detect and address deviations, and record any/all changes to project data; 3) Consider disallowing use of data outside the given ranges unless justification is given; and 4) Retain all information regarding such QA/QC measures, including their Standard Operating Procedure for such issues, summary of ranges, summary of all data inputs outside of range, summary of any interactions between relevant parties regarding flagged data, summaries of any changes to data,	A project proponent captures primary data using a farmer logbook, and compares such data against a typical range for the given parameter. Any significant deviation from the range is flagged by the project proponent, and project implementation staff are required to provide rationale for why the value is outside of the expected range. Where the project proponent determines that a sufficient explanation has been given, the out-of-range value is adopted. Otherwise the out-of-range value is substituted with the most conservative value within the given pre-determined range. The decision made by project staff is documented. The VVB is presented with all requisite data.

		and should make all such data available to the VVB and Verra.	
	Data integrity	A Standard Operating Procedure (SOP) should be created to handle data for each project. This should clearly identify how data are captured, and moved between various systems, and whether, when, by whom, and how such data has been altered since being ingested into project digital systems. Such systems should be auditable and should be made available to the VVB and Verra.	A project proponent makes all suggested data available to the VVB. This enables the VVB to understand the project's data architecture and flow of data through the systems and into the project documentation. The VVB can then undertake spot checks, choosing certain farms and tracing raw data through the systems, confirming the project proponent followed the SOP, and confirming the results appear reasonable in the circumstances.
	Validation of accuracy of digital analysis	Project proponents using dMRV should provide some analysis of the accuracy/error rates of the digital systems they are deploying. Project proponents should consider developing an error threshold for their systems, and a rule whereby they would replace any data that fails to meet such requirements.	A project outsources dMRV to a third-party software provider. The third-party software provider uses an RS-informed, GIS-enabled software tool. The third-party software provider undertakes their own validation and has a threshold of 80% accuracy, whereby they test specific analysis functions and only use them where the system performs with an 80% accuracy rate. Any specific datapoint which is found to fail the threshold is also discarded, and the project proponent is directed to use alternative datapoints for the given parameter.

APPENDIX 2: N_2O CORRECTION FACTOR

All fields that employ changes in irrigation must account for N_2O emissions associated with such changes by applying an N_2O correction factor, irrespective of whether there are any changes in volumes of nitrogen applied. An N_2O correction factor has been derived from the emission factors (kg N_2O-N/t N) from Table 11.1 (Updated) in Chapter 11, Volume 4 of the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*. The difference between the aggregated default value emission factors for continuously flooded rice fields and rice fields with single or multiple drainage was converted from N_2O-N into N_2O emissions using the emissions factor for N_2O-N to N_2O. Table 6Table 6 below demonstrates the values used in the calculation and the approach. All emissions factor values in the table below are taken from Table 11.1 (Updated) in Chapter 11, Volume 4 of the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*.

Table 6: Values used in calculation of N_2O correction factor (adapted from IPCC, 2019)

Emission Factor	Aggregated		Disaggregated		
	Default Value	Uncertainty Range	Disaggregation	Default Value	Uncertainty Range
EF1 for N additions from synthetic fertilizers, organic amendments, and crop residues, and N mineralized from mineral soil as a result of loss of soil carbon (kg N_2O-N/kg N)	0.01	0.001–0.018	Synthetic fertilizer inputs[1] in wet climates	0.016	0.013–0.019
			Other N inputs[2] in wet climates	0.006	0.001–0.011
			All N inputs in dry climates	0.005	0.000–0.011
EF1FR for flooded rice fields[3] (kg N_2O-N/kg N)	0.004	0.000–0.029	Continuous flooding		0.000–0.010
			Single and multiple drainage		0.000–0.016
EF3PRP, CPP for cattle (dairy, non-dairy, and buffalo), poultry, and pigs (kg N_2O-N/kg N)	0.004	0.000–0.014	Wet climates		0.000–0.026
EF3 PRP, SO for sheep and “other animals” (kg N_2O-N/kg N)	0.003	0.000–0.010	Dry climates		0.000–0.006

Disaggregation of EF1 and EF3PRP, CPP by climate (based on long-term averages): Wet climates occur in temperate and boreal zones where the ratio of annual precipitation to potential evapotranspiration is greater than 1, and tropical zones where annual precipitation is greater than 1000 mm. Dry climates occur in temperate and boreal zones where the ratio of annual precipitation to potential evapotranspiration is less than 1, and tropical zones where annual precipitation is less than 1000 mm. (Figure 3.A.5.1 in Chapter 3, Vol. 4 in IPCC (2019) provides a map subdividing wet and dry climates based on these criteria.) In wet climates, EF1 is further disaggregated by synthetic fertilizer N inputs and other N inputs.

1. This emission factor should be used for synthetic fertilizer applications, and fertilizer mixtures that include both synthetic and organic forms of N.

2. Other N input refers to organic amendments, animal manures (e.g., slurries, digested manures), N in crop residues, and mineralized N from soil organic matter decomposition.

3. Disaggregation of EF1FR: Single and multiple drainage also include alternate wetting and drying. Disaggregated EF1FR for rain-fed and deep-water systems is not provided due to lack of data. EF1 should be used for upland rice.

EF1: Uncertainty range of disaggregated EF1 based on the 95% confidence interval of fitted values. Uncertainty range of aggregated EF1 is based on the 2.5th to 97.5th percentile of the dataset

EF1FR, EF3PRP, CPP, and EF3PRP, SO: Uncertainty ranges are based on the 2.5th to 97.5th percentile

For EF2, see guidance in *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*, Chapter 2, Table 2.5.

APPENDIX 3: ADDITIONAL GUIDANCE FOR SURROGATE PROCESS MODELS

Recent research has demonstrated that Surrogate Process Models (also called model emulators) can leverage the power of well-calibrated process models while reducing the data burdens of full process modeling. This methodology allows Surrogate Process Models for Quantification Approach 1 provided the modeling is done in accordance with VM0042 (Table 8, section 8.3) and VMD0053, and with the requirements set out in Section 8.1 of this methodology.

Figure 1 in VMD0053 outlines the steps for using process-based models for GHG quantification. In addition to those steps, the following steps must be taken when using Surrogate Process Models in this methodology:

Step 1: Model selection. The process model used to develop the Surrogate Process Model must be publicly available, shown through peer-reviewed publications to be able to simulate changes in both CH4 and N2O emissions from rice production systems under the management systems for which the surrogate model is being developed, and the steps to create the surrogate model are described in detail.

Step 2: Model Calibration. There are two options for the model calibration step of Surrogate Process Model. The first option is to calibrate the process model prior to creating the Surrogate Process Model. The second option is to first develop the Surrogate Process Model and then calibrate the Surrogate Process Model. Both options are applicable to this methodology. However, the model calibration procedure must clearly state:

1. How the Surrogate Process Model is built off the underlying process model
2. The parameter sets derived from the calibration are used in the validation step and
3. Data used in calibration and validation are separate.

Step 3: Model Validation. Validation of the Surrogate Process Model must follow the same procedures as outlines in VMD0053, namely declaration of practice categories requiring evaluation, project domain and collection of data for validation of the Surrogate Process Model performance and uncertainty. Project domain will be declared by definition of crop functional groups, climate zones and soils (soil texture and clay content).

Step 4: Validation Reporting. Model validation reports (MVRs) produced by Surrogate Process Model must be assessed and approved by an Independent Modeling Expert (IME) following the same procedures described in VMD0053 Appendix 1.

APPENDIX 4: DOCUMENT HISTORY

Version	Date	Comment
Draft	11 June 2024	Initial version